ELECTRIC HEATING

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PREFACE

The utilization of electricity for heating purposes on a large scale is a development so recent that little information on the subject has yet been published outside of the trade periodicals. The wealth of printed matter concerning electric lighting practice only emphasizes the dearth of data regarding electric heating. Yet heat by wire seems destined to a far greater future than light by wire, not only as regards the amount of current consumed, but also in the intrinsic value of its service to mankind.

In his capacity as a load builder for central stations the author was early confronted with the lack of recorded facts about the how and why of electric heating. For his personal needs he correlated widely-scattered notes, simplified the technical treatment so that it would be intelligible to the sales prospect and brought into convenient form much of the knowledge required by the salesman of electric heating appliances.

This information has been so useful to the author that it was thought that it might also be of service to others in the industry, particularly since the electric cooking load has become so desirable to the central station. Hence this book.

Briefly, it aims to set forth in a practical way the many uses to which electric heat may be applied. The advantages and disadvantages of various kinds of heating loads are compared and many types of heating devices are explained. The relative operating costs of

electric and fuel-heated apparatus are shown by tables and simple calculations. Suggestions are given regarding approved methods of installing and using domestic and commercial ranges, bake ovens, water heaters and industrial heating devices.

Acknowledgement is here made of the courtesy of many manufacturers in supplying cuts used to illustrate typical equipment.

E. A. WILCOX.

San Francisco, July, 1916.

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raise the temperature of one pound of any substance one degree Fahrenheit.

A clear conception of the use of this unit of measurement is essential to the designer of heating apparatus, since it indicates the capacity for absorbing heat for a given temperature change. All the heat taken up in raising the temperature of a substance is given off when the body cools. The total heat absorbed by a body is equivalent to the product obtained by multiplying temperature difference, weight, and specific heat. It will be noted from the table in the back of the book that the specific heat of water (i.e., its heat absorbing power) is greater than that of most known substances.

Thermal Capacity.—The thermal capacity of a substance is the quantity of heat required to raise its temperature one degree. It is the product of its specific heat and mass. As the specific heat of water is unity, fifteen pounds of water has a thermal capacity of $15 \times 1 = 15$ B.t.u. Likewise the specific heat of cast iron being .1298, fifteen pounds of iron has a thermal capacity of $15 \times .1298 = 1.947$ B.t.u.

The Calorie.—Heating calculations are frequently expressed in calories instead of British thermal units. The French thermal unit, or calorie, is that quantity of heat required to raise the temperature of one kilogramme of water one degree Centigrade. It is equivalent to 3.968 British thermal units; or one British thermal units is equal to .252 calorie.

Mechanical Equivalent of Heat.—Heat and mechanical energy are mutually convertible. The number of foot-pounds of mechanical energy equivalent to one British thermal unit is the mechanical equivalent of heat. It has been established experimentally that one B.t.u. is equal to 778 foot-pounds, and on that basis it has been calculated that one horsepower is equivalent to 2545 B.t.u. per hour.

Relation to Electrical Units.—Where resistance is offered to the flow of an electric current the electric energy is converted into heat energy. The heat gen-

erated is proportional to the resistance of the conductor, the square of the current strength, and the length of time the current flows. It has been established experimentally that one ampere of current flowing through a resistance of one ohm for one hour will generate 3.412 B.t.u.. Since one ampere flowing one hour through a resistance of one ohm is equivalent to one watt-hour, 3.412 B.t.u. equals one watt-hour ($EIT = RI^2T$) or 3412 B.t.u. equals one kilowatt hour.

If it is desired to raise a certain quantity of a substance through a certain temperature range the number of kilowatt hours required for the operation may be calculated as follows:

$$\text{Kw-hr.} = \frac{\text{Degrees rise F.} \times \text{Pounds} \times \text{Specific Heat}}{\%\ \text{Efficiency} \times 3412}$$

Divide the number of kilowatt hours determined by the above calculations by the number of hours allowed for the operation and the result will be the kilowatts of heater capacity required for performing the work.

Latent Heat.—The quantity of heat which is absorbed by a body in a given state in converting it into another state without changing its temperature is termed its latent heat.

Latent heat of fusion is the heat absorbed in changing a body of a certain weight from a solid to a liquid without changing its temperature. When the operation is reversed the same quantity of heat is given off as was previously absorbed.

Latent heat of evaporation is the heat required to change a unit weight of a solid or liquid at a given temperature into a gaseous state at the same temperature. It is the heat that disappears during the change and which will reappear if the operation is reversed. Whereas it requires only 180 B.t.u. at atmospheric pressure to heat a pound of water from the freezing to the boiling point (termed sensible heat), it requires 970 B.t.u. (latent heat of evaporation) to convert the same quantity of water into steam at 212 degrees F.

The total heat of evaporation is the sum of the sensible heat and the latent heat of evaporation.

Radiation.—Heat passes from warm to cold bodies by three general methods,—radiation, conduction, and convection. Radiation of heat takes places between bodies at all distances apart and the heat rays proceed in straight lines until intercepted or absorbed by some object. The amount of heat transmitted varies inversely as the square of the distance from the source. The rate at which heat is given off or absorbed depends upon the character of the surfaces of the bodies as well as upon their relative temperatures. Dark and rough surfaces radiate and absorb heat more readily than smooth and polished ones. Radiant heat passing through air or other gases does not affect their temperature to any appreciable extent.

Conduction.—The transfer of heat between two bodies or parts of a body in direct contact with one another is termed conduction. It differs from radiant heat in that it does not necessarily travel in straight lines, and in its gradual rather than instantaneous transfer. The quantity of heat conducted is proportional to the cross sectional area, to the temperature difference, and to the character of the material.

Metals are, in general, better conductors of heat than other materials, although they vary to a very great extent. The conducting power of stone is less than one per cent that of copper, and iron is about 3500 times as good a conductor as air.

Convection.—The transfer and diffusion of heat in a fluid mass through the motion of the particles of the mass is termed the convection of heat. The particles must be in constant motion in order to insure uniform temperature of the mass. When the particles come into contact with hot bodies the mass will be warmed in proportion to the freedom of circulation in the fluid.

Air is usually heated in a room by circulation of the air particles and bringing them into contact with heated surfaces. The better the circulation of air

against these surfaces the more uniform will the room temperature become.

Comparisons of Fuel and Electric Heat.—The relative heating values of fuels are often compared with electric heat. For instance, it may be shown that with coal having a heating value of 14,000 B.t.u. per pound and costing $5 per ton, manufactured gas having a heating value of 600 B.t.u. per cu. ft. and costing $1 per thousand cu. ft. and electricity having a heating value of 3412 B.t.u. per kilowatt hour and costing one cent per kilowatt hour, one cent will buy 56,000 B.t.u. of coal heat, 6000 B.t.u. of gas heat, and 3412 B.t.u. of electric heat. However, the fact must not be overlooked that all fuel apparatus is naturally less efficient than electric apparatus. With average efficiencies of say 10 per cent for coal, 20 per cent for gas, and 70 per cent for electric apparatus, the purchasing power of one cent under the above assumed prices and heating values would be 5600 B.t.u. of coal heat, 1200 B.t.u. of gas heat, and 2388 B.t.u. of electric heat.

The following table will be of assistance in making hasty comparisons of the B.t.u. value of fuel and electric heat. Efficiencies lower than 50 per cent are seldom, if ever, encountered in electric applications and are therefore omitted from the table.

B.t.u. Purchasing Power of One Cent.

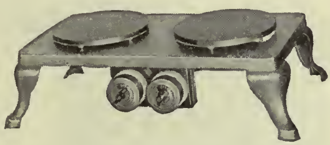
Efficiency of Apparatus in %	100	75	50	30	20	10
14,000 B.t.u. Coal—						
$ 5.00 per ton	56,000	42,000	28,000	16,800	11,200	5,600
$10.00 per ton	28,000	21,000	14,000	8,400	5,600	2,800
600 B.t.u. Gas—						
$1.00 M. cu. ft.	6,000	4,500	3,000	1,800	1,200	600
$1.50 M. cu. ft.	4,500	3,375	2,250	1,350	900	450
Electricity—						
1c per kw.-hr.	3,412	2,559	1,706	....	....	...
2c per kw.-hr.	1,706	1,279	853	....	....	...
3c per kw.-hr.	1,137	853	568	....	....	...
5c per kw.-hr.	682	512	341	....	....	...

Actual experience proves that many careful calculations do not work out in practice. One might assume from the above figures, for instance, that the cost of using a gas range would be at least five times as

in greater quantities than any other electrically heated device known.

The principal advantages of the electric iron over the old fashioned sad iron are saving in time and steps, even heat distribution, freedom from smoke, grease and soot, absence of excessive heat, and ease with which it may be used in any part of the house. Irons varying in weight from 3 pounds to 9 pounds and in capacities from 200 watts to 675 watts are available for domestic use.

Electric Stoves.—Both the disc and open coil type are manufactured in various sizes and capacities. The disc stove has a metallic heating surface and delivers

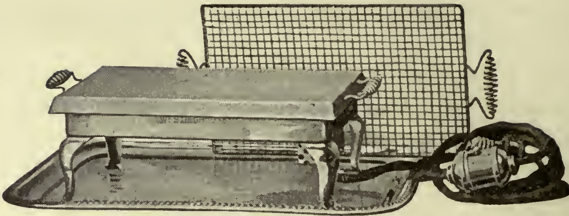


G. E. Twin Plate Disc Stove.

heat to the utensil by conduction. The open coil stove gives off radiant heat from exposed coils which are usually imbedded in grooves of porcelain or mounted above metallic reflectors.

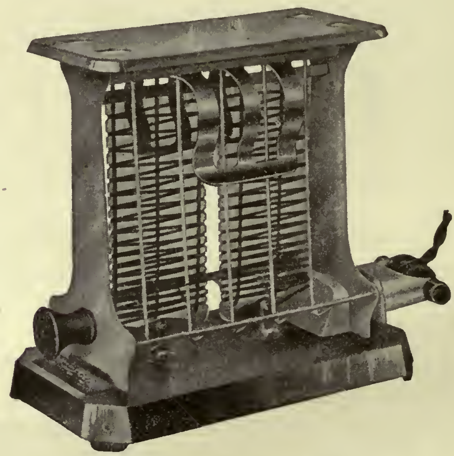
Electric stoves are useful for many household purposes in place of gas or alcohol burners. They are suitable for heating water for various purposes, or for doing light cooking. They are safe, convenient and durable. For domestic lamp socket use they are seldom larger than six inches in diameter and 600 watts in capacity.

Toaster Stoves.—Two distinct types are made—horizontal and vertical. Toast made on the horizontal type will be produced quickly but will not be toasted through so well unless the bread be dry. Toast made below radiant coils or in the vertical type toasters will be produced slowly but will be toasted thoroughly. Vertical toasters are usually provided with a warming shelf on top to keep toast or other food warm.



Westinghouse Horizontal Toaster Stove.

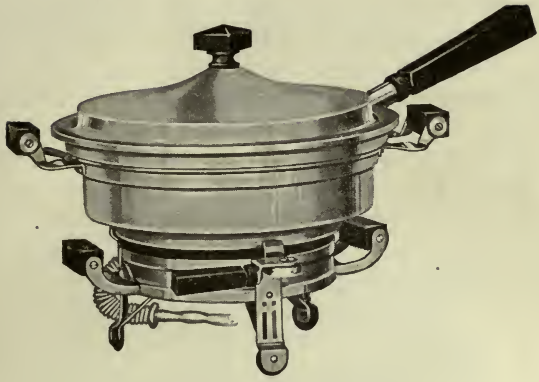
One great advantage of electric toasters is that they may be used on the dining room table instead of in the kitchen. From 400 to 600 watts are usually required for operating toasters.



Hot Point Vertical Toaster.

Chafing Dishes.—These frequently have an outer pan in addition to the food pan for use as double boilers. The food pans are made in two and three-pint sizes. The capacities vary from 250 to 600 watts. A wide variety of styles and ornamental types are available.

Electric chafing dishes are obviously safer to operate than alcohol or other flame types, and furthermore they give off no disagreeable odors or fumes.



Universal Chafing Dish.

Coffee Percolators.—Coffee made in an electric percolator is rich in flavor, free from grounds, and contains less caffein and other harmful elements than boiled coffee. Starting with cold water, strong coffee may be prepared in from ten to fifteen minutes.

Hot Point Percolator.

Electric percolators in all styles, shapes and character of ornamentation and in sizes varying from four to nine cups are available. They usually require from 450 to 600 watts. They are ideal for use on the dining

room table because they are attractive in appearance and also keep the coffee hot with practically no attention.

Tea Samovars.—The housewife who prides herself on her tea-making is pleased with a device where the tea-ball may be drawn up when the infusion is just right and a beverage served of fine flavor, and free from the bitter tannic acid taste that results from boiling tea-leaves in an ordinary pot. It is especially desirable for the afternoon tea because it can be operated in the living room. It furthermore does away with the disagreeable odors, fumes and dangers of alcohol or other fuel types.

Tea samovars are usually made in 5, 6 and 7 cup sizes and in capacities varying from 400 to 500 watts.

Tea Kettles.—Two and three pint sizes are usually made, requiring from 400 to 550 watts for operation. They are convenient and dainty for heating water for the tea service. They make an attractive addition to the table and possess the charm of a modern household luxury.

Simplex Dining Room Set.

Table Cooking Outfits.—Single disc stoves supplied with a variety of hollow-ware utensils are called unit-sets, dining room sets or combination stoves. Coffee percolators, tea samovars, chafing dishes, nursery milk warmers, frying pans, tea kettles, griddle plates, and other utensils are included in the various sets.

These devices bring electric cookery within reach of every one and encourage a better understanding of

its cleanliness, and convenience. For the hostess who does her own cooking the table cooking outfits are ideal. They are an ornament to any sideboard or table.

Electric Grills.—Many handy devices for cooking on the dining room table, or in the sick room, and which are attractive and convenient, are made by various heating appliance manufacturers. The Hotpoint El Grillo is a useful table device. It may

Hot Point Grill Stove.

be used for light toasting, frying and broiling as well as for boiling. Two of these operations may be carried on at one time as the utensils may be placed both above and below the glowing coils. It has a capacity of 600 watts and the dimensions of the heating element and pans are 4¼ by 8½ inches.

The Westinghouse toaster stove is really a small complete cook stove. It may be used for broiling, frying, toasting, boiling or making griddle cakes. The stove is 5¼ by 9 by 3⅝ in. high and consumes 500 watts.

The General Electric radiant grill may be used for frying, stewing, toasting, and broiling. This device consumes 600 watts.

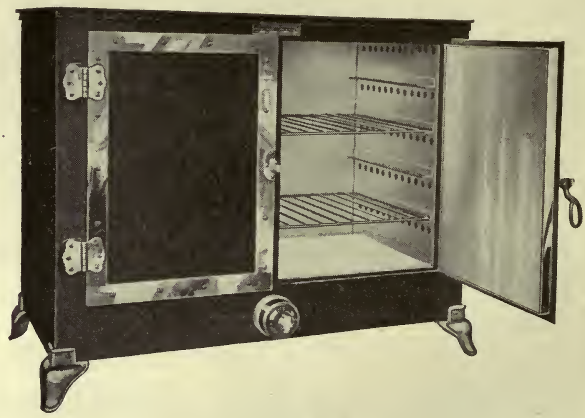
Food Warmers.—Food warmers are made in a variety of portable styles, shapes, and sizes, and may be used on the table or sideboard.

Simplex nickel or silver plated food warmers of the following sizes and capacities are available:

Oval shape, 10 in. by 14 in.	170 watts
Oblong shape,	
10 in. by 14 in.	200 "
10 in by 18 in.	250 "
Oblong shape (extra heavy)	
10 in. by 14 in.	200 "
10 in. by 18 in.	250 "
10 in. by 26 in.	400 "

Simplex Food Warmer.

Plate Warmers and Hot Closets.—A variety of shapes and sizes of plate warmers and hot closets are manufactured to order to fit available spaces, or standard portable types may be used.



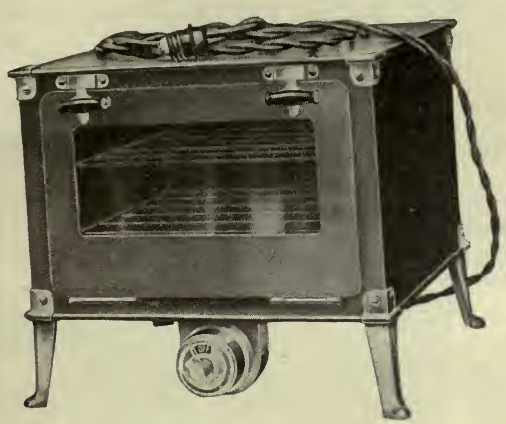
Hughes Plate Warmer.

In estimating the size of a plate warmer closet a shelf space of at least 10½ in. should be allowed for ordinary dinner plates and a height of 6 in. for twelve in a pile.

On account of the relatively low temperature required inside the oven, the current consumption is usually low, especially if the walls are well insulated against heat losses.

Bake Ovens.—Devices like the small Hotpoint lamp socket bake ovens (El Bakos) are useful for light

baking operations. The inside dimensions are 11 in. by 10½ in. by 7½ in. and they consume 600 watts on the high heat. They are of steel construction with nickel



Hot Point El Bako.

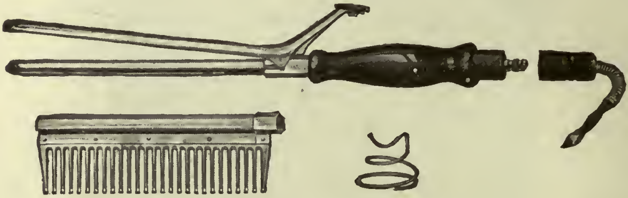
trimmings and the walls are lined with mineral wool to retain the heat. These ovens have practically all the inherent advantages of larger electric ovens.

Simplex Nursery Milk Warmer.

Nursery Milk Warmers.—These consist of a water vessel and cover, a milk bottle, and a nipple. They are designed for quick heating and are made in capacities varying from 300 to 500 watts. They are ready for use at any time—day or night. The 500 watt size

will heat a bottle of milk in about four minutes or boil a pint of water in about six minutes.

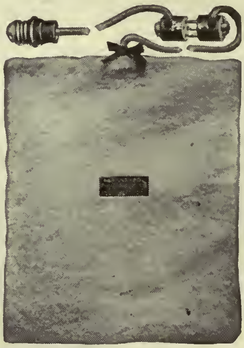
Curling Iron Heaters.—These are desirable on account of their absolute cleanliness, convenience, and safety. They are made in capacities varying from



Universal Curling Iron and Hair Dryer.

60 to 90 watts and in plain or ornamental types. The Westinghouse electric curling iron is equipped with a heating element inside the iron which consumes 15 watts.

Warming Pads.—For local applications of heat to the body electric pads are rapidly superseding the hot water bottle and similar devices. These pads are



Simplex Warming Pad.

usually made of soft padded cloth although some of the new Hotpoint pads are made of either rigid or flexible metallic materials. The Westinghouse pads are 11 in. by 15 in. and have an outer rubber cover. The Simplex pads have an eiderdown cover and are made in two sizes, 12 in. by 15 in. and 15 in. by 24 in.

The American warming pad is 12 in. by 13 in. Warming pads are generally provided with regulating switches giving three degrees of heat. The capacities vary according to dimensions from 50 to 100 watts maximum. The American sweating blanket is 5 ft. long by 18 in. wide and requires 800 watts.

Immersion Heaters.—These appliances are useful in the home that is not provided with a constant supply of hot water. By fastening to the lamp socket and submerging the heater in water or other liquid the sub-

Hot Point Immersion Heaters.

stance can be brought to a boil very quickly. Inasmuch as the heating element is placed directly in the liquid the efficiency of operation is high. They are handy for shaving and similar purposes. Heaters of various shapes and capacities are available.

Other Household Devices.—A few of the better known heating and cooking devices are mentioned for reference purposes.

Egg boilers are convenient because they can be used on the table and given personal supervision.

Fry pans and saute pans designed for use on the dining room table are useful.

Soup tureens are handy for keeping soups and other prepared foods at the proper temperature for serving.

The Hotpoint utility outfit which comprises a three pound iron provided with a stand on which it may be inverted for cooking, and a receptacle for inserting a curling iron is useful for the roomer or traveler.

The foot warmer is a handy device for use in rooms with cold floors. If placed under a desk or

Universal Egg Cooker

table it will keep an occupant warm even when the room is comparatively cold.

Air radiators of both the radiant and convection types are useful in small rooms and in cold corners. A separate chapter is, however, devoted to the subject of air heating.

CHAPTER III

INSTALLATION OF HEATING APPARATUS.

Correct Installation.—This is essential for ranges, water heaters, and other heating devices. If wires are too small, the service will be poor. If the appearance of the work is not good, the user will be dissatisfied. If proper protection against electric shocks is not afforded, the customer may be in constant fear. If a range, for instance, is not placed in such a position that it can be conveniently operated by the cook or housewife, she may form mental prejudices that will be difficult to overcome. Intelligent supervision and careful inspection of all heating installations will be of mutual benefit to all concerned.

Wiring for Heating Apparatus.—The Code of the National Board of Fire Underwriters should be adhered to as closely as possible in wiring for heating apparatus. Furthermore, local city and state rulings have a distinct legal status the importance of which should not be overlooked. Unfortunately the National Code rulings which apply to the installation of heating service are in some cases burdensome, and in others not strict enough.

All wiring should be done in a neat and workmanlike manner so that an electric installation will not detract in any way from the appearance of the premises. Electric ranges, water heaters, and other heating devices on the market usually look attractive, but if they are not properly connected and installed the general appearance may be bad.

Carrying Capacities of Wires.—The allowable carrying capacity of conductors operating under pressures of 120 volts, two-wire, and 120-240 volts, three-wire, are given in Table I for convenient reference.

Table I.

Maximum Allowable Wattage Carrying Capacity.

Size B. & S. Gauge.	Area Circ. Mils.	—Rubber Covered— 120 volt. 2-wire.	120-240 v. 3-wire.	—Weather Proof— 120 volt 2-wire.	120-240 v. 3-wire.
0000	211,600	27,000	54,000	39,000	78,000
000	167,800	21,000	42,000	33,000	66,000
00	133,100	18,000	36,000	27,000	54,000
0	105,500	15,000	30,000	24,000	48,000
1	83,690	12,000	24,000	18,000	36,000
2	66,370	10,800	21,600	15,000	30,000
4	41,740	8,400	16,800	10,800	21,600
6	26,250	6,000	12,000	8,400	16,800
8	16,500	4,200	8,400	6,000	12,000
10	10,380	3,000	6,000	3,600	7,200
12	6,530	2,400	4,800	3,000	6,000

Wires of sufficient size to conform to the allowable carrying capacities in the above table will conform to the Underwriters' Code but may prove too small to insure good service. This will be true if the run is a long one because in the above table no account is taken of its length.

Table II shows the drop in voltage (below 120) that may be figured per hundred feet of both two and three-wire circuits. The calculations are based on an assumed pressure of 120 volts for two-wire service and 120-240 volts impressed on a three-wire circuit.

Table II.

Wattage Load on End of Line.

No. B. & S. Gauge	2500 2-wire.	2500 3-wire.	5000 2-wire.	5000 3-wire.	7500 2-wire.	7500 3-wire.
0000	.204	.102	.409	.204	.619	.306
000	.258	.129	.515	.258	.774	.386
00	.325	.162	.650	.325	.975	.487
0	.410	.205	.819	.410	1.229	.615
1	.517	.258	1.033	.417	1.550	.775
2	.651	.326	1.303	.651	1.954	.977
4	1.036	.518	2.071	1.036	3.107	1.553
6	1.647	.824	3.294	1.647	4.941	2.471
8	2.618	1.309	5.237	2.618	7.855	3.927
10	4.164	2.082	8.329	4.164	....	6.246
12	6.623	3.312	....	6.623	....	9.935

No. B. & S. Gauge	10,000 2-wire.	10,000 3-wire.	15,000 2-wire.	15,000 3-wire.	25,000 2-wire.	25,000 3-wire.
0000	.818	.409	1.238	.619	2.044	1.022
000	1.030	.515	1.548	.774	2.576	1.288
00	1.200	.650	1.950	.975	3.250	1.625
0	1.638	.819	2.458	1.229	4.096	2.048
1	2.066	1.033	3.100	1.550	5.166	2.582
2	2.606	1.303	3.908	1.954	6.515	3.257
4	4.143	2.071	6.214	3.107	....	5.178
6	6.588	3.294	9.882	4.941	....	8.235
8	....	5.237	....	7.855	....	....
10	....	8.329	....	....	....	....
12	....	....	....	....	....	....

Correct Voltage.—For heating apparatus this is important. Many complaints may be obviated by supplying energy at a pressure as near as possible to the rated voltage of the apparatus. Low voltage results in slowness of operation, and excessively high voltage is likely to cause burn outs.

Assume a heating element rated at 1100 watts and 110 volts is supplied with energy at a pressure of 100 volts. The resistance of the element is therefore: $R = E/I = 110/10 = 11$ ohms.

At 100 volts pressure the quantity of current flowing would be $I = E/R = 110/11 = 9.1$ amperes and the wattage dissipated in heat would be $W = EI = 9.1 \times 100 = 910$ watts. The efficiency of operation of the element, therefore, would be $910/1100 = 82.7$ per cent, whereas the voltage was supplied at only $100/110 = 91$ per cent of the normal rating.

Voltage readings should always be made at the terminals of the heating device at no load and at full load, otherwise the drop in voltage in the service leads or interior wiring may be overlooked, and a wrong impression gained.

Methods of Wiring.—How to wire a building for heating service should be carefully considered before the actual work is undertaken. Exposed wiring with knobs and cleats is safe and cheap but is seldom used because of its unsightliness. Moulding work is sometimes installed in old buildings but unless the work is done extremely well it may look unattractive. The concealed knob and tube method is often used in both new and old buildings and the work may usually be done at reasonable cost. Rigid or flexible conduit, or steel armored conductor wiring are generally considered to be the best, although the most expensive methods.

Exposed Knob and Cleat Wiring.—This is often used in wiring for heating and cooking service and in places where appearance is of little consequence it is one of the cheapest and best. The wires may be single braid rubber-covered or slow burning weather-proof.

In cellars or other places exposed to moisture rubber-covered wire must be used.

Wooden Moulding Wiring.—Where a neat appearing low-priced job is required this construction may well be used. Its use in damp places is however prohibited by the Underwriters. Single braid rubber-covered wire is required. For first class work hard wood moulding, matching in finish the trim of the room, can be used.

Wiring in Metal Moulding.—As this is restricted to circuits carrying not more than 1320 watts it is seldom employed for heating or cooking circuits. Single braid rubber-covered wire may be used for this class of work. Metal moulding must always be grounded permanently.

Concealed Knob and Tube Wiring.—In frame buildings where a low cost of installation is essential the wires may be installed within floors and partitions. Wires can ordinarily be concealed in this manner more cheaply than by any other method. Single braid rubber-covered wire may be used.

Rigid Iron Conduit.—This is approved for both exposed and concealed work. Ordinarily it is probably the best, although the most expensive. Double braid, rubber-covered wire must be used in rigid conduit. The same conduit may contain as many as 4 two-wire or 3 three-wire circuits. Stranded wire in sizes larger than No. 6 is customarily used for rigid conduit work. Rigid conduit must be permanently grounded.

Table III.

Size of Wire, B. & S. Gauge.	Size of Conduit, Inches.					
	Two Wires in Conduit.			Three Wires in Conduit.		
	Short Run.	Medium Run.	Long Run.	Short Run.	Medium Run.	Long Run.
10	½	¾	¾	¾	1	1
8	¾	¾	1	1	1¼	1¼
6	1	1	1¼	1	1¼	1¼
4	1	1¼	1¼	1¼	1¼	1½
2	1¼	1½	1½	1¼	1½	2
1	1¼	1½	2	1½	2	2
0	1½	2	2	2	2	2
00	1½	2	2	2	2	2½
000	2	2	2	2	2½	2½
0000	2	2	2½	2	2½	3

Table III shows the size of double braid rubber-covered wires that can readily be pulled into conduit.

Flexible Metallic Conduit.—For all kinds of exposed or concealed work such construction is often preferable to rigid conduit. The installation of flexible conduit can be made easier, quicker, and more cheaply than can riged conduit. The same code rules apply to flexible as to rigid conduit. It must be securely grounded. Double braid rubber covered wire is required. Flexible metallic conduit may be used to advantage in finished houses and in frame buildings.

The sizes of wire that may be accommodated in flexible steel conduits are given in table IV.

Table IV.

Nominal Inside Diam. In Inches.	Largest Wires Accommodated. One Wire.	Two Wires.	Three Wires.
½	8	12	..
¾	2	10	12
1	00	0	8
1¼	200,000	4	6
1½	400,000	1	3
2	800,000	200,000	00

Flexible Steel Armored Conductor.—Here a cable consisting of rubber-covered wires is protected from injury and to a certain extent from dampness by two layers of flexible steel armor. It may be obtained leaded or unleaded. The leaded cable differs from the unleaded in that it has a lead covering between the wire and the steel armor to protect it from excessive dampness. Both the leaded and the unleaded cables are made with single and multiple conductors of almost any gauge wire. The leaded cable is approved for all classes of work, open or concealed, in fireproof or nonfireproof buildings, and in new or old houses. The unleaded cable is approved and may be used for open or concealed work in places not subject to moisture.

For wiring old buildings steel armored conductor can be used to great advantage. It can be run with utter disregard to contact with pipes or other materials and may be fished for long distances. It can be installed quicker and with less cutting away of the walls and floors than either rigid conduit, flex-

ible tubing, or concealed knob and tube work. Steel armored conductor should always be carefully grounded.

The Main Entrance Switch.—For three-wire heating circuits this should always be of the fused type with the neutral fuse coppered.

Control Switch.—Heating devices should be provided with control switches that will indicate at a glance whether the circuit is open or closed. The switch should be mounted on the device or on the wall immediately adjacent to it so as to be easily accessible. It should be of the enclosed knife blade or snap switch type and so designed as to entirely disconnect the heat-type appliance at the wish of the operator.

Grounding.—The frames of all heating appliances, especially those of the larger types, should be carefully grounded, whether they are connected to two-wire or three-wire circuits. Satisfactory grounding may be accomplished by connecting the frame of the device to a water pipe. If the appliance is operated from a three-wire grounded neutral system the frame may be connected to the neutral wire. In case of doubt as to the character of the ground on such a system, the neutral may be grounded, in turn, to some convenient water pipe inside the building.

When a rigid or flexible metallic conduit or steel armored conductor job is installed, the frame of the device may be grounded to the conduit or steel armor; provided, of course, the conduit or armor is itself grounded elsewhere.

Ranges in Apartment Houses and Flats.—In this case separate circuits from the main switchboard are necessary. Each circuit must be fused but in the case of three-wire circuits the neutral should be coppered.

Main service wires and switches supplying group cooking loads are never called upon to carry the entire connected load. Apartment houses equipped with ten or more ranges are never known to have a demand greater than one-fourth the connected load. The larger the number of ranges supplied from a single

service the less will be the demand in proportion to the load connected. This is a condition seldom met with in supplying other classes of electric service and one for which no provision has been made in the Underwriters' Code. It is obvious, however, that to install service leads, main switches, fuses, etc., of sufficient carrying capacity to handle the total connected load would be of no advantage, and would involve needless expense.

The Proper Position for a Range.—The range should be located where it can be operated with ease and convenience. If it is placed where the light is bad, in an inaccessible corner of the kitchen, or where the cook or housewife has to walk back and forth a greater distance than that to which she has been accustomed, a serious prejudice may be created in her mind. An electric range is often installed in a kitchen by the side of a coal, gas, wood, or oil range, the latter being left in, either for auxiliary use or for want of a better place for storing the old equipment. When this condition is met, every endeavor should be made to secure permission to place the electric range in the most advantageous position. Otherwise the customer will have a tendency to use the appliance most favorably located for most of her work.

CHAPTER IV

ELECTRIC COOKING.

The March of Progress.—Modern civilization's advance may be clearly indicated by the progress in methods of cooking. Wood was the first material to be used as a fuel. Water was boiled in a kettle suspended over a log fire and meats were broiled on a spit, or roasted in the embers, for many hundreds of years. When it was found that coal produced a more uniform and hotter fire, and was far more desirable than wood, another era of progress was marked. The old fashioned fire place gave way to the more modern kitchen range. Then came fuel gas, which may be considered a product of coal, and the gas stove made its appearance. Although the use of gas obviously involved more danger and was somewhat more expensive, it was found to be quicker and far more convenient.

Crowning success was achieved, however, when the electric method was perfected, and the bridging of space between the historic fuel fire and the modern heat produced without flame was accomplished.

Advantages of Electric Cooking.—The extent of the improvement brought about by the electric range is almost unbelievable. The heat is under absolute control. The operator knows and commands the temperature at all times. The wasting of heat has been reduced to a minimum. The units or burners generate the heat right where it is used, and very little loss takes place. The heat utilized in the oven is generated on the inside, and as its walls are heavily insulated with material of low thermal conductivity, there is practically no opportunity for useful energy to escape.

Facility of Operation.—The electric range is easier to operate and can be regulated with a much greater degree of accuracy and certainty than the fuel range.

Being clean, safe and labor-saving, its use promotes greater cleanliness and comfort. It produces no excess heat, smoke or fumes to vitiate the atmosphere, and does away with the constant attention and anxiety of the fuel fire. Cooking utensils, furthermore, may always be kept clean and free from smoke and soot on both the inside and outside.

Hughes No. 60 Range (for Large Family Use).

Uniformity is attained in the electric range because it will always produce the same results under the same operating conditions. For instance, the oven has to be opened but twice for each operation—once when the food is inserted, and again when the cooking is completed. The operator has only to watch the clock while the food is cooking. This advantage partially removes the objection that many persons have to a low oven, which, with fuel stoves, requires constant bending over to examine the condition of the

food. Any housewife, of even moderate intelligence, should be able to master the essential features of the operation of an electric range in a short time by simply reading the card of instructions that is sent out by the manufacturers with each range.

Special Advantages.—The individual operations in which the electric range outclasses every known type of fuel stove, are baking, roasting and broiling. The heat being uniformly distributed in all parts of the oven, insures even baking and browning. It will bake bread, cake, and pies that are most attractive in appearance. They will always have just the right color, will contain more nourishment, and remain fresh longer. Roasts should always be prepared in an open pan containing no moisture, and basting is unnecessary in the electric oven. Sufficient moisture and meat greases will collect in the pan during the operation to prevent burning, and to provide material for gravy. The roast itself will come out of the oven uniformly browned on top, bottom and sides, if no basting is done. In both roasting and broiling operations the meat is seared, thereby retaining its natural juices, and making it more delicious, nutritious and attractive to serve.

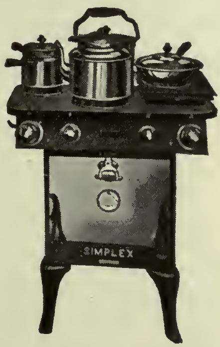
Reduction in Meat Shrinkage.—Many experiments have been made in actual practice to show that there is less shrinkage in meats prepared electrically than by any other means. The meats sear over as soon as placed in the oven; there is no burning away of the fats and juices; and a saving of from 15 per cent to 18 per cent in the actual weights of the meats is effected. The tremendous economy in household expense that is made possible by the use of the electric range is apparent if we consider a family whose meat bill has averaged $15 per month and a saving made of 15 per cent in the meat shrinkage by the use of electricity. Meat costs in this family would be reduced $2.25 per month with the exercise of no additional self denial.

Assume an eight pound roast is placed in a 1600 watt electric oven and roasted 2½ hours. The current

consumption at high heat would be 4 kilowatt hours, but by proper manipulation of the oven switch not over half this amount, or 2 kilowatt hours, would be actually consumed. The saving in weight of the meat over gas or coal cooking would amount to at least one pound. With current costing three cents per kilowatt hour and meat twenty cents per pound the actual saving to the housewife in cooking the roast electrically would be as follows:

1 lb. of meat saved at 20c.	$ .20
2 kw-hr. at 3c cost	.06
Actual saving	$0.14

Model G Hot Point Range.



Simplex 5-K Range.

Important to Use Proper Utensils.—Only flat bottomed utensils should be used for surface cooking on the electric range. Air is a poor conductor of heat, and consequently, the closer the heating unit can be brought to the bottom of the utensil, the greater will be the efficiency of operation. The necessity is particularly apparent in ranges making use of an element of the enclosed type, where the heat is transmitted to the food from a hot surface through the bottom of a utensil. If direct metallic contact is not secured the efficiency will be tremendously impaired; slow operation will result; and the housewife will become displeased.

Agate or enameled ware should never be used on enclosed type elements. Iron, copper, or aluminum

vessels will be found far more efficient. On the other hand, agate, enameled ware, and black bottomed iron utensils have been found very satisfactory for use with open type elements. Polished metallic bottom surfaces reflect and do not take up the heat from a radiant type element as do black surfaces. Contrarywise, highly polished sides and tops retain heat in a utensil much more efficiently than do dark or rough surfaces. If the bottom of any kind of utensil is corrugated, hollowed out or warped it cannot be expected to give satisfactory results.

Economy in Range Operation.—Food prepared on the cooking surface will not burn on the inside of the utensil as long as any moisture remains in the vessel, because heat is applied only at the bottom and never at the sides. For this reason, the amount of water usually required to keep food from burning may be reduced and the operations performed more easily and quickly. The food will be steamed thoroughly, and the natural sweetness and flavor will be cooked into the food, rather than boiled out into the water poured away. Water absorbs more heat than any commonly known substance, and a little economy in the use of water will effect considerable saving in both heat and electricity.

Users of electric ranges should be encouraged to use water drawn from the hot water storage supply for cooking purposes. Water taken from the top of a tank is obviously purer than that taken from the water mains because the tank acts as a natural settling basin for the collection of all impurities and sediment. If hot water is used in preparing foods, the operations may be done more quickly, and considerable saving in current consumption effected.

One very common method of effecting economies in the operation of a range, is to place as many foods as possible in the oven instead of on the cooking surface. The oven, being heavily insulated, retains practically all the heat generated and the usual losses that attend cooking on the surface units are thereby done away with.

Water for laundry work, washing, bathing, and other domestic purposes cannot be heated as economically on an electric range surface as by other means. If the housewife desires, however, she may successfully boil clothes by placing an ordinary copper bot-

Hughes Junior Range (for Early Training of Housewife).

tom boiler over two of the range discs. Quicker action will result if the boiler is kept covered, and a heavy paper wrapped about the sides of the vessel.

The saving that may be effected by skilful use of the individual three-heat switches is often little understood by the average woman. She should be trained to know that the low heat consumes but one-quarter, and the medium heat one-half as much current, as the high heat. Food brought to the boiling point on high heat should be retained at this temperature at

low or medium heat. A boiling temperature higher than 212 degrees F. cannot be obtained in an open vessel and food will cook just as quickly when boiling slowly as when boiling rapidly.

Elimination of Kitchen Chimneys.—If fuel is burned in a kitchen a chimney is naturally required. On the other hand the expense of installing a chimney may be obviated by using an electric range. Even with gas the harmful products of combustion must be removed as shown by the following from page 20, Technical Paper 109, U. S. Bureau of Mines:

"Natural gas, when burned with sufficient oxygen for complete combustion, forms carbon dioxide and water vapor. Each cubic foot of natural gas burned produces a little over 1 cubic foot of carbon dioxide and a little more than 2 cubic feet of water vapor. Carbon dioxide is an irrespirable gas and should not be allowed to accumulate in a room. Water vapor also should be removed, because it has a depressing effect if present in still, warm air in sufficient proportion and tends to make the walls, ceilings, curtains and other objects in a room dirty because the dust is entrained by it and settles on the objects."

"The only way to remove these two gases is by means of a vent leading from the stove to the house chimney. It is absurd for any manufacturer of stoves to claim that these two gases are practically absorbed or eliminated in any other way."

Operation by Servants.—Care should be exercised in placing a range in the hands of a professional cook. This type of individual is frequently a difficult person to handle. He seldom favors anything new. He is prone to form intense prejudices; and will often refuse to make an intelligent investigation of new apparatus, especially when he has not been previously consulted. He is always a very powerful factor in matters concerning the management of a kitchen, and his position should not be overlooked.

If he dislikes equipment placed in his charge he may damage it, refuse to handle it properly, or cause the operating cost to run up excessively. Disastrous results are certain to accrue if the cook's attitude is unfavorable.

Repeated experience has proved that the housewife who does her own cooking is the most desirable user of an electric range. She will be, as a rule, thoroughly alive to its advantages, will practice the many little economies that are possible, and will generally become a "booster" for electric cooking.

Attention to Range Users.—When ranges are first installed the users should receive very careful attention. It must be remembered that the manipulation

General Electric No. S-3 Range.

of an electric range is entirely new to the average housewife. If something about the apparatus is out of order; if the best results are not secured at the start; or if some of the many little economies that may be practiced are overlooked and the first month's bill proves higher than has been anticipated, an erroneous mental impression may be formed that may prove difficult to correct. If troubles are not rectified or explained away, they will become magnified as time passes, and the housewife may finally become seriously prejudiced. Furthermore, every electric range placed is naturally watched by the many friends, relatives and neighbors of the user. In as much as it is generally conceded that the best advertising medium

is the satisfied customer, it is well worth while to give the user early and painstaking attention.

Electric Cooking in Schools.—The encouragement of electric cooking in the domestic departments of educational institutions will foster the more rapid introduction of electric ranges in the homes. In order that correct impressions may be created in the minds of the students, it is highly important that the equipment be intelligently selected, that the apparatus be properly installed, and that the service be the best attainable.

Domestic Science Classroom, Westminster College, Salt Lake City.

For classroom work, small rather than large individual disc stoves should be installed, because only a small amount of food need be prepared at one time. Double boilers and frying pans should be provided with each stove, and these utensils should be of a size to fit and of a kind that will operate properly with the particular type of disc stove that is installed. Small individual bake ovens are comparatively inexpensive, occupy little space, produce excellent results, and may be recommended for well-equipped departments.

In some school where domestic science is taught complete electric cooking equipments have been provided and meals prepared and served cafeteria style during the noon hour periods. The income from the

nominal charge made for these meals has been adequate, in a number of instances, to pay the operating cost of the electric kitchen, as well as of the entire department.

Other institutions have gone further, and arranged for the use of electric flat irons, water heaters, and other labor-saving devices. At least one complete electric range should be made the part of any modern domestic science room equipment. The comparatively few hours during which classes are in session make the operating cost of electrically operated installations very small. Although the income from this class of

McDonald Apartments, Boston, Equipped with Hughes Ranges.

business is not large, the load is of an off-peak character, and the results are far-reaching. The favorable impression created by equipping domestic science departments in this manner cannot but have a beneficial effect upon the school and a credit to the individuals in charge.

Electric Cooking in Apartment Houses.

Adaptability of Electric Range.—The electric range seems to be peculiarly adapted for use in apartment houses. The character of construction of the buildings, the mode of living of the tenants, and the many recognized advantages of the electric range make it much superior to the fuel burning stove. A resume of the most essential qualifications of this type of apparatus and the better conditions that may be brought about where it is installed for apartment house cooking service should not be out of place in these pages.

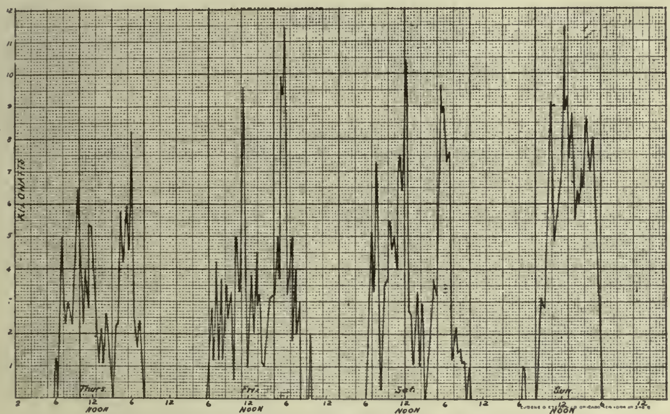
Jensen Apartments, Great Falls, Mont. (Equipped with Simplex Ranges.)

Economy in Space.—In the design of the modern apartment house every foot of space is valuable and the architect must plan to utilize it to the best advantage. His efforts in this direction seem to have resulted in the laying out of very small kitchens which are often stuffy and poorly ventilated. The electric range is best fitted to meet these recognized conditions for several reasons: It is compact in construction, and as the exterior never becomes hot enough to burn the woodwork it may be placed against the wall and thereby take up less space. The unbearable heat of a fuel range in a small kitchen is eliminated. There is no combustion in the electric range and it neither throws off poisonous fumes nor takes up the life-giving oxygen from the air.

Expense Saved.—The initial outlay required for the installation of chimneys and gas plumbing may be entirely eliminated. When the building is once occupied the periodical expenditures incident to repainting, retinting and repapering, may be cut in half. The very nature of the electric range, which creates no products of combustion, and which overcomes the

smoke, moisture and grease nuisances peculiar to the fuel range, makes the frequent refinishing of interiors unnecessary.

Elimination of Hazard.—Where fuel stoves are used there is constant danger of fire. Gas offers the menace of asphyxiation and explosion. The careless opening of a valve, a temporary cut-off of the main supply, or a little mistake of the cook or housewife may



Typical Apartment House Cooking Load Curve, 24 Ranges, 75 kw. Connected, Maximum Demand 11½ kw.

result disastrously. In as much as the electric range produces no flame, and neither utilizes nor gives off any explosive or poisonous gas, its use does away with all danger of loss of life or property.

Convenient for the Tenant.—On account of the absence of soot and burned foods, the utensils used on an electric range are easier to cleanse both inside and outside. Silverware in an apartment house never tarnishes as it does where gas is used. Unlike gas, electricity throws off no sulphur fumes.

Another condition that goes to make the electric range popular, is that an auxiliary supply of hot water is usually available for use in the apartment house, and may be utilized for cooking operations to attain quick results.

Desirable Central Station Load.—From an operating standpoint the apartment house business is very desirable for the central station company. The load is, for the most part, of an off-peak character. The load factor and diversity factor are both unusually attractive. The maximum demand is frequently shown to be not over one-sixth of the connected load. Compared with apartment house lighting and elevator loads the business is obviously more desirable.

Preparation of Food.

Knowledge of Cooking Valuable.—For those interested in the sale of electric ranges or in the building up of electric cooking loads, a general understanding of how foods are prepared, why it is necessary to cook them, and the best methods to employ, will be of value. If one endeavors to interest a housewife in an electric range, he should know something about the use to which it is to be applied, otherwise he will not readily gain her confidence. Anyone familiar with the following paragraphs as well as with the natural advantages of electric heat, will be able to show the average housewife wherein electricity is superior to fuel heat in performing the various cooking operations suggested.

Reason for Cooking.—The cooking of food has much to do with its nutritive value. Many articles which are quite unfit for nourishment when raw are nutritious when cooked. It is also a matter of common experience that a well cooked food is wholesome and appetizing, whereas the same material badly cooked may be both unhealthful and unpalatable.

Purposes of Cooking.—There are three chief purposes of cooking. The first is to change the mechanical condition so that the digestive juices can act upon the food more freely. The second is to make it more appetizing by improving the appearance or flavor, or both. Food which is attractive to the taste quickens the flow of saliva and other digestive juices, and thus aids digestion. The third is to kill any disease germs, parasites, or other dangerous organisms it may con-

tain. This is often an important object, and applies to both animal and vegetable foods.

Cooking of Meats.—For the most part meat is either boiled, stewed, fried, broiled or roasted. In general, it is probably true that cooking diminishes the ease of digestion of most meats. It may also remove considerable quantities of the nutrients.

Boiling of Meat.—If it is desired to heat the meat enough to kill bacteria in the inner portions of the cut, the piece must be exposed to the action of heat for a long time. If it is brought slowly to a boil, a good broth will be obtained, but the meat will be tough and tasteless.

If a piece of meat is plunged into boiling water or very hot fat, the albumen on the entire surface of the meat is quickly coagulated and the crust thus formed resists the dissolving action of water and prevents the escape of the juices and flavoring matters. Thus cooked, the meat will possess the desired meaty taste but the resulting broth will not be considered good.

It is impossible to make a rich broth and have a juicy highly flavored piece of meat at the same time. If the meat alone is to be used, it should be plunged into boiling water and kept at that temperature for about ten minutes, after which the cooking should be continued at about 180 degrees F. until the tissues become tender.

Stewing of Meat.—If both the broth and the meat are to be used, the process of cooking should be quite different from that of boiling. In stewing, the meat should be cut into small pieces so as to present relatively large surface area and, instead of being quickly plunged into hot water, should be put into cold water, in order that the juices and flavoring materials may be dissolved. The temperature should then be slowly raised until it reaches about 180 degrees F. where it should be kept for several hours. Treated in this way the broth will be rich, and the meat tender and juicy.

Roasting of Meat.—The principle difference between roasting and boiling, is in the medium in which the meat is cooked. In boiling the flesh is surrounded

by hot water, whereas in roasting it is surrounded by hot air and acted upon to some extent by radiant heat. In both operations, if properly conducted, the meat fibers are cooked in their own juices.

When the meat only is to be eaten, either roasting, broiling, or frying in deep fat is a more rational method than boiling, for the juices are largely conserved in the meat.

Cooking of Vegetables.—Vegetables baked, roasted, fried or boiled, are used for preparing a large variety of dishes. The most common method of cooking is that of boiling in water. The steaming of vegetables is often resorted to, but the results are similar to those of the boiling process.

The simpler the method of cooking and serving vegetables the better. A properly cooked vegetable will be palatable and readily digestible. Poorly cooked, water soaked vegetables generally cause serious digestive disturbances. All vegetables should be thoroughly cooked, but the cooking should stop while the vegetable is yet firm. As long as the vegetable is kept at a temperature above 125 degrees F. changes continue to go on in the vegetable substance. The most marked of these are in the starch, and in the odor, color, and flavor of the vegetable. Overcooking changes and toughens the texture of vegetable foods, destroys the coloring matters, and volatilizes or otherwise injures the substances which contribute to its flavor.

Cooking of Breads and Pastries.—In breads, cakes, pastries and other foods prepared from flour, the aim is to make a palatable and higher porous substance that can be more easily digested than the raw materials could be. Sometimes this is accomplished simply by means of water and heat. The heat changes part of the water content into steam, which, in trying to escape, forces the particles of dough apart. The protein (gluten) of the flour stiffens about the tiny bubbles thus formed and the mass remains porous even after the steam has escaped. More often, however, other ingredients, such as yeast and baking powder,

are used to "raise" the dough. The baking powder gives off carbon dioxide gas, and the yeast causes fermentation in the dough and produces carbon dioxide. This gas acts the same as steam, only much more powerfully.

Baking of Bread.—Bread is placed in the oven as a heavy uniform mass, and comes out a light body of increased volume with a crisp, dark exterior—the crust—and a firm, spongy interior—the crumb. The crumb naturally heats more slowly than the crust. The moisture which it contains prevents its temperature from rising much above the boiling point of water (212 degrees F.) When first put into the oven the yeast begins to work but a temperature of 158 degrees F. kills it. The gas in the dough, however, continues to expand, and forcing its way outward, enlarges the loaf and gives it a spongy appearance. Meanwhile the crust becomes hard and dark and the heat changes its starch into stiff gum and sugar and dries out the moisture. The brown color is due to chemical changes known as "caramelization."

Baking Temperatures.—The heat in the oven should not be too great, or the outside of the bread will harden too quickly, and the crust will be thick and hard before the interior is done. Furthermore, the gas expanding in the crumb will be unable to escape through the crust and will lift up the latter, leaving great holes beneath it.

The temperature of an oven and the time required for baking depends upon the size of the loaves and the character of the dough. Small biscuits or rolls can stand a much hotter oven, and quicker baking, than large bread loaves. For ordinary purposes, a temperature of from 400 degrees to 500 degrees F. is satisfactory for a pound loaf of bread. An experienced cook can tell when an oven has reached the proper heat by inserting his hand, but a pyrometer, (as a thermometer for measuring high temperature is called) makes a much better guide for the ordinary operator.

CHAPTER V

THE ELECTRIC RANGE.

Demand for Domestic Ranges.—Interest shown in the domestic range is increasing more rapidly than in any other single heating appliance. In line with the attention now being given to this type of apparatus, and the rapidly growing market for it, the manufacturers of heating apparatus are making many improvements in both their original designs, and character of product. A number of concerns which have heretofore confined their activity solely to the production of fuel stoves, have taken up the manufacture of electric ranges. The result of these developments has been a 50 per cent reduction in range prices during the past five years, greater reliability in the heating units, a larger diversity of designs from which choice of equipment can be made, and simpler and more desirable standards of construction.

Essential Qualifications of the Electric Range.—The features of the domestic range which make its use desirable to the customer, the central station, and to those having the marketing of the product in hand, are generally agreed upon by all who have given the subject their serious consideration. The range, first of all, must be of substantial and durable construction, and of pleasing appearance. The designs must be standardized as rapidly as possible with the economic object in view of lower costs and increasing production. Simplicity of operation and ease of handling and cleaning are also essential. The heating elements must be rugged, reliable and efficient. Furthermore, they should be so designed as to be easily, quickly, and cheaply renewed whenever troubles develop. The ovens must be well insulated with heat resisting material, readily accessible, and easily cleaned. Some provision for broiling, either in the oven or on the cooking surface, is generally considered necessary.

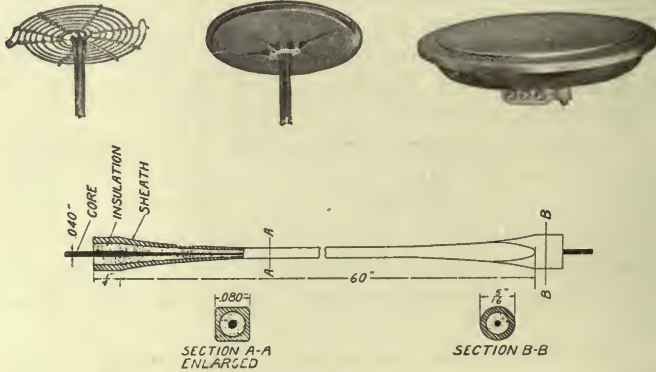
It is of interest to note that the early types of ranges were so designed as to keep down the connected load and the central station demand as much as possible, whereas the present tendency is to neglect this phase of the design in favor of larger capacity units capable of doing quicker work. This is a step in the right direction. The natural diversity of the range load, and the short period demands which it creates are of little moment in comparison with the necessity for greater speed of operation. Furthermore, there is no reason for believing that a range of high rated capacity will consume any more energy in performing its work than one of lower capacity. The efficiency may be approximately the same with either design.

Types of Heating Units.—Heat is usually generated in electric range units by the passage of current through high resistance wires or strips of metallic ribbon. Heating elements in common use may be classified into three different types—first, the enclosed type, second, the radiant type, and third, the reflector type.

Enclosed Type Elements.—These usually consist of a resistance wire or ribbon, enclosed between mica or asbestos strips, or surronded with an enamel or other electric insulating material of high thermal conductivity. The element is usually enclosed within, bound upon, or otherwise imposed against, a metal disc or grid which takes up the heat, and in turn dissipates it. The heat generated in such a unit is transmitted from the metal surface to the cooking utensil and thence to the food by conduction. When this type of unit is used in an oven, however, the heat is transmitted to the food through the air by convection.

It is obvious that this type of element takes a little longer to start heating than do open elements, because the mass of material of which it is composed has to first absorb a certain quantity of heat before it can begin throwing it off. It is claimed, however, that this type of element will lose less of the heat generated during a longer period of operation than the open coil element. There are certain apparent advan-

tages in having the hot wires hermetically sealed, such as the prevention of oxidation and mechanical injury, but unless the insulating materials are able to withstand extreme temperatures they are liable to serious damage, if the voltage is higher than normal, or if the element is connected for a long period without some means of carrying away the excess heat that is generated. Most enamels melt before they reach a temperature of 1650 degrees F. (Cherry red).



Process of Manufacture of General Electric Sheath Wire Heating Elements.

Radiant Type Units.—These are usually coils of high resistance wire laid in grooves, or supported on the surface of insulating material. Current passing through this wire brings it to a high temperature, and the heat is transmitted for the most part as radiant heat direct to the utensil or the food to be cooked. Some of the heat, however, is absorbed by the insulating support and some is given off as convected heat both from the support and from the wire itself, the percentage varying with the design of the unit and its composition. In a well designed unit much of this convected heat is finally taken up by the food.

Radiant type units begin to throw off a large amount of heat almost as soon as the current is turned on. The heat in the coils, is visible on account of the high temperature. The nature of the radiant heat

given off makes it possible to use the ordinary kitchen utensils to better advantage on the open than on the enclosed type elements. The coils being exposed, however, and the supports, as now manufactured, being somewhat brittle, this type of unit is to some extent liable to mechanical injury, short circuits, and grounds. It is also harder to keep clean than the enclosed type element.

Hughes Open-Type Element.

Reflector Type Element.—Use is here made of the heat reflection principle. It usually consists of exposed coils of wire surrounded by air and supported adjacent to a bright metallic reflector. Part of the heat generated in the coils passes directly to the cooking utensil or to the food in the same manner as from the ordinary radiant type element. Another portion of the heat travels in the opposite direction until it reaches the polished surface, where it is reflected back on its course to the cooking utensil. A small percentage of the energy is, of course, given off as convected heat and some passes away through the reflector.

This type of element heats quickly, makes possible the use of most ordinary kitchen utensils, and pro-

duces a visible heat in the coils. It is, however, more subject to mechanical injury than the enclosed type element. The reflectors, although they can be easily and cheaply replaced, are also likely to become discolored and become inefficient on account of the intense heat. The future development of a cool reflector, however, may do away with the latter objection.

Types of Electric Ranges.

A large variety of electric ranges are manufactured in this country. They are available in many styles and capacities, and at various prices. Each of them has been developed with certain individual characteristics in design or operating features, having some advantages over those of other makes, but all of which could not possibly be incorporated in any single design. This chapter is therefore devoted to descriptions of the most prominent makes of electric ranges in order to convey a general understanding of the design, construction and individual characteristics of the types now available.

Hughes Ranges.—This make of electric range has been on the market for a number of years. It is made in a large variety of shapes and sizes, in either the high oven, low oven, or cabinet types, and in capacities ranging from 4140 to 10,340 watts. The frame is constructed of black heavy gauge sheet metal supported on cast iron legs. The legs, top, and fittings are nickel finished in most of the designs. The general construction is rugged and of handsome appearance.

The heating elements are of the open or radiant type and consist of coils of resistance wire held in place below the cooking surface by means of a grooved composition block. This block is in turn, surrounded by another block of asbestos compound having high thermal resistance. The units may be easily removed with a screw driver and pliers.

The oven is thoroughly insulated with mineral wool. The interior of the oven is finished in black enamel. The doors are of the drop shelf type and are usually trimmed in nickel and white porcelain enamel

Thermometers are fitted in these doors. There are two heating elements in the oven—one in the top, and the other in the bottom. Each of these units is regulated by a three heat switch. The top unit is used for broiling. An enameled tray and rack for this purpose are provided with each range. Some of the higher priced ranges are supplied with white porcelain enamel splashers around the cooking surfaces, which add materially to the appearance of the equipments.

HUGHES RANGES.

Type. No.	Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
C-2	Cabinet	2-880	18x12x12	1	1500	
				1	880	4140
C-3	Cabinet	2-880	18x12x12	1	1500	
				1	1100	
				1	880	5240
C-4	Cabinet	2-1100	18x18x12	1	1500	
				1	1100	
				1	880	5680
C-18	Low oven	2-880	18x12x12	1	1500	
				1	880	4140
No. 27	Low oven	2-880	18x12x12	1	1500	
				1	880	4140
No. 30	Low oven	2-880	18x12x12	1	1500	
				1	1100	
				1	880	5240
No. 33	High oven	2-880	18x12x12	1	1500	
				1	1100	
				1	880	5240
No. 37	Low oven	2-1100	18x18x12	1	1500	
				1	1100	
				1	880	5680
No. 40	Low oven	2-1100	18x18x12	1	1500	
				1	1100	
				2	880	6560
No. 44	High oven	2-1100	18x18x12	1	1500	
				1	1100	
				2	880	6560
No. 47	Cabinet	2-1100	18x18x12	1	1500	
		Warmer-	21¼x20x9	1	1100	
				1	880	5680
No. 48	Low oven	2-1100	18x18x12	1	1500	
				2	1100	
				3	880	8540
No. 50	Cabinet	2-1100	18x18x12	1	1500	
		Warmer-	21¼x20x9	1	1100	
				2	880	6560
No. 56	Cabinet	1-1800	18x18x8	1	1500	
		2-1100	18x18x12	1	1100	
		Warmer-	21¼x20x9	2	880	8360
No. 60	Cabinet	1-1800	18x18x8	1	1500	
		2-1100	18x18x12	2	1100	
		Warmer-	21¼x20x9	3	880	10340

Hughes No. 50 Cabinet Range.

Simplex Ranges.—These ranges were first put on the market about nineteen years ago. The modern domestic types usually consist of an oven, a broiler, and several disc heaters. They are made up in either the low oven, or cabinet type, and in capacities ranging from 3100 to 8200 watts. They are finished in black japan. The general construction is rugged and compact.

The heating units are of the enclosed type, the resistance wires being embedded in enamel, and fused to the under side of the cast iron discs. The discs protrude slightly above the top of the range, and are provided with a simple locking device by which the utensils are clamped fast to the heating surface to insure good contact. The units are fastened to the frame with thumb screws. The utensils included

with each range are made of heavy copper, nickeled outside and tinned inside.

The broiler is mounted on the cooking surface. It consists of a corrugated heating plate slightly inclined toward the front, from which an outlet carries off the juices for serving with the meat. A separate smooth top fits on the broiler for making griddle cakes, etc.

The oven is made of Russia iron with japan finished iron frame and nickel plated trimmings. The walls are heavily insulated with corrugated asbestos and provided with a vent. The heating elements in both

SIMPLEX RANGES.

Type.		Oven		Cooking Surface.		Total
No.	Style.	Wattage.	Dimensions.	No. of Elements.	Wattage (of Each)	Wattage of Range.
4K	Low oven	1300	15x12x11½	1	440	
				2	735	3210
5K	Low oven	1300	15x12x11½	1	440	
		1300	9x12 broiler	1	735	3775
6K	Low oven	1600	15x18x11½	2	440	
		1300	9x12 broiler	1	735	4515
7K	Low oven	1600	15x18x11½	1	440	
		1300	9x12 broiler	2	735	4810
8K	Low oven	1600	15x18x11½	2	440	
		1300	9x12 broiler	2	735	5250
9K	Low oven	1600	15x18x11½	1	440	
		1300	9x12 broiler	2	735	
				1	1100	5910
14K	Low oven	2400	21½x19x13	1	440	
		2200	12x18 broiler	1	735	
				1	1100	
				1	1300	8175
21K	Cabinet	1600	15x18x11½	2	440	
		1300	9x12 broiler	1	735	
		200	15x15x7 warmer			4715
22K	Cabinet	1600	15x18x11½	1	440	
		1300	9x12 broiler	2	735	
		200	15x15x7 warmer			5010
23K	Cabinet	1600	15x18x11½	2	440	
		1300	9x12 broiler	2	735	
		200	15x15x7 warmer			5450
24K	Cabinet	1600	15x18x11½	1	440	
		1300	9x12 broiler	2	735	
		200	15x15x7 warmer	1	1100	6110
31K	Cabinet	1600	15x18x11½	2	440	
		1300	9x12 broiler	1	735	4515
32K	Cabinet	1600	15x18x11½	1	440	
		1300	9x12 broiler	2	735	4810
33K	Cabinet	1600	15x18x11½	2	440	
		1300	9x12 broiler	2	735	5250
34K	Cabinet	1600	15x18x11½	1	440	
		1300	9x12 broiler	2	735	
				1	1100	5910

Simplex No. 7-K Range.

top and bottom are of the enclosed grid type, and are controlled by a single three-heat switch. The oven door is of the drop shelf type, fitted with an indicating thermometer.

General Electric Ranges.—Ranges of this make have been on the market for a considerable time and the makers may be credited with having done a great deal of development work. These ranges are now manufactured in two standard types—the "R" type and the "S" type, either of which are available in either the high oven, low oven, or cabinet styles.

The "R" type was first developed. It is of heavier and better construction, provided with special "Calorox" oven insulation, and is likewise more expensive.

The "S" type is a later development. The frame of the range is made by a fuel stove manufacturing concern. The heating units and other electrical features are provided by the General Electric Company.

General Electric No. R-2 Range.

The ovens are equipped with separate top and bottom heating elements and provision made for broiling inside. The standard oven dimensions on each range is 18 in. by 18 in. by 12 in.

It is of interest to note that all the heating elements used on ranges made by this company have been of the enclosed type. The "D" type unit which has been discarded for some time, consisted of a ribbon wire resistance clamped between mica strips and fastened to the bottom of the element. The units used on the "R" and "S" type units are made up by pouring molten iron around sheathed wire. This so called "sheated wire" consists of a small hollow wire enclosing a fine resistance wire, the space between being filled with an insulating material of high thermal con-

GENERAL ELECTRIC RANGES.

No.	Type. Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
R-1	Low oven	2-1000	18x18x12	2 3	1000 200*	4600
R-2	High oven	2-1000	18x18x12	2 3	1000 200*	4600
R-3	Cabinet oven	2-1000 1-300 warmer	18x18x12	2 3	1000 200*	4900
R-4	Cabinet oven	2-1000	18x18x12	2 3	1000 200*	4600
S-1	Low oven	1-1000 1-1500	18x18x12	3	1000	5500
S-2	High oven	1-1000 1-1500	18x18x12	3	1000	5500
S-3	Cabinet oven	1-1000 1-1500	18x18x12	3 1	1000 200*	5700

(*cookers)

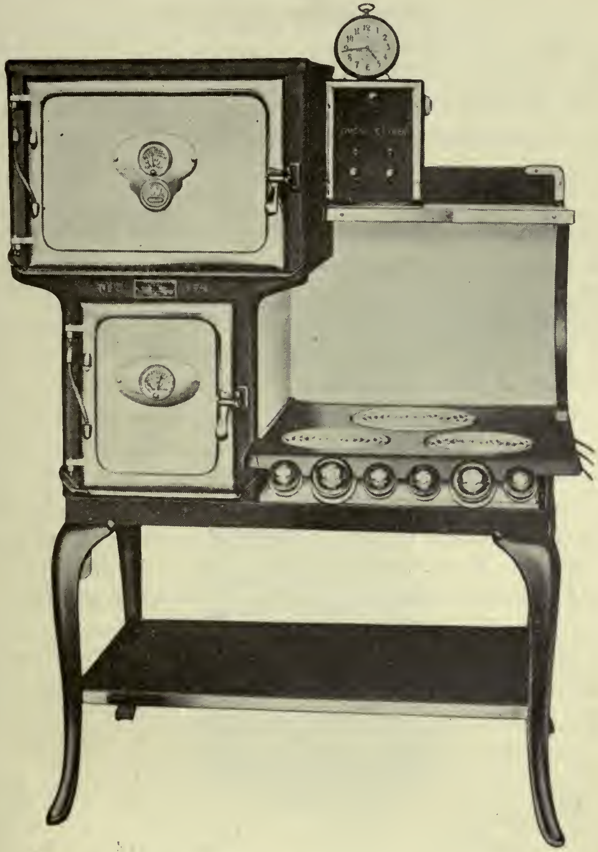
ductivity (presumably aluminum or other metallic oxide).

Vegetable cookers may be substituted for any one or all of the top heating units if desired. These cookers are heavily insulated and consume little current. They are especially useful for preparing stews, vegetables, cereals, etc.

All the elements on the stove have plug connections and may be changed by anyone without the use of any tools.

Westinghouse Ranges (Copeman Patents).—These ranges are at present manufactured in two standard styles—the low oven type known as the 2-19, and the cabinet type known as the 3-19. Either of these ranges may be obtained in either plain or nickel finish, and may or may not be provided with the special automatic feature. The cabinet type is always equipped with white porcelain enamel splashers around the cooking surface. The construction of both ranges is substantial. The legs and frame are of cast iron, and other parts of sheet steel.

Open or radiant type elements consisting of coils of resistance wire, held in place in spiral grooved composition blocks are used. The cooking surface on each of these ranges consists of two 8 in. 1000 watt units, and one 10 in. 2000 watt unit. The latter is so connected that the low heat utilizes the inner third



Westinghouse 3-19 Automatic Range.

of the surface, medium the inner two-thirds of the surface, and high the entire 10 in. surface.

The ovens are thoroughly insulated with mineral wool. The oven doors open to the side. The interior dimensions of the oven are 18½ by 13½ by 16 in. The cabinet type range is provided with a small boiling oven (10⅜ in. by 13½ in. by 11½ in.) in addition to the large oven. Provision is made also for broiling in the large oven.

Either type range may be equipped with a relay, whereby the current will be automatically turned off

WESTINGHOUSE RANGES.

Type. No.	Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage. (of Each)	Total Wattage of Range.
No. 3-19	Cabinet	2-1000	18½x13½x16	1	2000	
		1-850	10⅜x13½x11½	2	1000	6850
No. 2-19	Low oven	2-1000	18½x13½x16	1	2000	
				2	1000	6000
No. 406	Low oven	1-1000	16x12x11½	2	1000	
		1-660				3660

when the ovens reach a certain desired temperature. The cabinet type range, furthermore, may be equipped with a clock device, whereby the current may be automatically turned on in the oven at any desired time.

The number 406 range is smaller than the two standard styles and of less expensive construction.

Olston Ranges.—These ranges have been on the market for several years and are made in one-oven, two-oven, and three-oven types and in capacities varying from 1980 watts to 4620 watts. They are constructed of sheet iron, enameled in gray, and trimmed in nickel. The ovens are mounted on sheet metal legs, and are easily accessible without stooping.

No heating elements are furnished for top cooking, but flush receptacles for attaching disc stoves and other heating devices, are provided. The oven elements are of the open type.

OLSTEN RANGES.

Type. No.	Style.	Oven Wattage.	Oven Dimensions	Total Wattage of Range.
1	Low	1980	11½x11½x18	1980
2	Low	2970	(11½x11½x18	
			(11½x11½x18	2970
3	Low	4620	(11½x11½x18	
			(11½x11½x18	
			(13⅝x12½x21)	4620
4	Wall type.	Same as No. 1.		
5	Wall type.	Same as No. 2.		

The ovens are heavily insulated with mineral wool and are provided with drain cups to collect the excess moisture caused by condensation. The doors open to the side. The ovens are controlled by flush snap switches and the temperatures are regulated by thermostatic devices, which automatically maintain any desired temperatures for which they are set. When

the required heat is generated, the current switches off, and when the oven cools a few degrees, the current is switched on, thus maintaining a constant temperature. Pilot lamps, mounted over the temperature control dials, indicate at all times whether or not current is being consumed.

No. C Good Housekeeping Cooker.

Good Housekeeping Cocker.—This device, which has been on the market for several years, has been known as the automatic steam cooker, or the Berkeley cooker. Although the principle of operation has not been changed, its mechanical construction has been greatly improved.

The cylindrical outside shell is 14 inches in diameter and made of polished sheet steel. The cast iron base and top are trimmed in nickel. Two 8 inch enclosed type disc elements of 1000 watts capacity each, may or may not be mounted on the cooker surface. The top of the cooker is 31½ in. from the floor. A

GOOD HOUSEKEEPING COOKER.

Type. No.	Style.	Cooker Pot Wattage.	Cooker Pot Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
A	Cooker	550	14 gallons	None		550
C	Cooker	550	14 gallons	2	1000	2550

small ovenette, for use over one of the discs, may be obtained with the cooker. The space provided in the cooker is approximately 13 inches deep and has a capacity of about 14 gallons. The walls and cover are heavily insulated with mineral wool and granulated roasted cork.

The cooking compartments consist of two cylindrical copper jackets welded one within the other with a slight space between, from which the air is exhausted, and a small quantity of water and ether introduced. An enclosed type heating element of 550 watts capacity is fastened to the bottom of the outer jacket. A diaphragm, the buckling of which, actuates a contact lever controlling the flow of current in the heating element, is made a part of the outer compartment jacket. At a temperature of 250° F., a steam pressure of 15 pounds is produced causing the diaphragm to buckle, thereby actuating the lever, and cutting off the current to the heating element. At 220° F. the pressure is reduced with the result that the element is again connected. This action is continued as long as the cooker is in service. An automatic clock device, for turning the current on in the cooker at a predetermined time, is also provided with each equipment.

Globe Ranges.—The Globe Stove and Range Company which has confined its efforts to the production of wood, coal and gas stoves, for many years has recently taken up the manufacture of electric ranges. Those which have thus far been placed on the market possess several novel and attractive features. The desire of the average women for bright enamel and nickel trimmings has been catered to in the finish of the ranges. The sheet metal parts are made of twenty gauge Armco iron with white enamel on one side, and ground coat on the other.

The ovens are insulated with three inches of "Sil-o-cel" and lined with sixteen gauge Armco iron.

One-quarter inch steam packing gaskets insulate the oven from the front frame of the stove, and also separate the inner and outer casings of the door. Heavy latches used on the oven doors make them practically air tight.

Globe No. B-5 Range.

The heating elements used in the oven are of the enclosed type in the bottom, and of the open coil radiant type in the top, for broiling operations. The top surface elements are unique in that they combine, in a measure, the features of both the open and en-

closed types. Resistance wires, wound in flat helical coils, are fastened in grooved porcelain plates, and protected with thin cast iron plates. These plates are grooved to correspond with the position of the

GLOBE RANGES.

No.	Type. Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
A2	Low oven	1-1500) 1-2000)	19¼x19¾x13	2	1500	
	Low oven	1-1500) 1-1000)	11½x19¾x13	2	800	10,600
A3	Cabinet	1-1500 1-1000	11½x19¾x13	2 2	1500 800	7,100
A4	Low oven	1-1500 1-1000	11½x19¾x13	2 2	1500 800	7,100
B1	Low oven	1-1500 1-1000	13¼x13¼x19¼	2 2 1	1500 800 330	7,430
B2	Cabinet	1-1500 1-1000	13¼x13¼x19¼	2 2 1	1500 800 330	7,430
B3 Special	Low oven	1-1500 1-1000	13¼x19¼x13¼	2 1	1500 800	6,300
B3	Low oven	1-1500 1-1000	13¼x19¼x13¼	2 1	1500 330	5,830
B4 Special	Cabinet	1-1500 1-1000	13¼x19¼x13¼	2 1	1500 800	6,300
B4	Cabinet	1-1500 1-1000	13¼x19¼x13¼	2 1	1500 330	5,830
B5	High oven	1-1500 1-1000	13½x19½x13½	2 1 2	1500 330 800	7,430

wires. It is therefore apparent that a utensil placed over one of the heating elements is heated by both radiant and conducted heat.

Estate Ranges.—The Estate Stove Company is recently bringing to bear its many years of experience in the construction of fuel stoves and ranges, in the manufacture of electric ranges. Three standard types have thus far been placed on the market. The ranges are of substantial construction, resembling the standard gas ranges in appearance. The cast iron parts are treated with a coat of ebonite, and the sheet metal parts are made of rust resisting steel. The oven doors and broiler pans are of white enamel, as are the splasher backs in the cabinet type ranges.

The cooking surface elements are of the enclosed type, consisting of nichrome wire, wound around mica

discs, and clamped between iron plates. These plates are connected by means of plugs which fit into receptacles and may be removed or connected as easily as any ordinary socket plug. The heating elements in the ovens are also of the iron clad type with the

No. 84 Estate Range (with Cookers Attached).

exception of the broiling elements, which are of the radiant type.

The ovens are of ample capacity for ordinary baking and roasting, and are heavily insulated. The doors, which open to the side, are strongly latched and fitted with thermometers. Broiling operations are performed in the ovens, except in the No. 84 cabinet range, which is provided with a separate broiling compartment mounted below the oven.

The cylindrical fireless cookers, which may be hinged to the legs of the cabinet type ranges and swung out of the way when not in use, are a special feature. These cookers are heavily insulated, have interior dimensions of 8 inches depth by 10 inches diameter, and consume 500 watts each.

ESTATE RANGES.

No.	Type. Style	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
83	Low oven	1030) 1370)	18x12x12	2-6½ in. 1-8 in.	650 1200	4900
84	Cabinet	1500) 2000)	18x18x12	3-6½ in. 1-8 in.	650 1200	
		1500	Broiler			8150
88	Cabinet	1500) 2000)	18x18x12	3-6½ in. 1-8 in.	650 1200	6650

Rutenber Ranges.—After several years experience in the manufacture of electric ranges the Rutenber Electric Company has adopted three standard low oven types which are made up in either plain or nickel finish.

No. 115 Rutenber Range.

The frames of the ranges are made of cast iron and the sheet metal parts of blue polished steel.

The heating elements are of the radiant type, consisting of coils of wire laid in grooves of a special

moulded clay compound. Each range is provided with two such elements.

The ovens are heavily insulated with rock wool and the interior walls are made of a special alloy.

RUTENBER RANGES.

Type. No.	Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage. (of Each)	Total Wattage of Range.
105	Low	2-1000	18x18x14	4	1000	6000
110	Low	2-800	18x18x14	3	1000	4600
115	Low	2-800	18x12x14	2	1000	3600

The doors open to the side, are heavily latched to prevent the loss of heat, and are fitted with standard oven thermometers.

Acorn Ranges.—Rathbone Sard & Company, which has been the maker of the well-known Acorn fuel ranges for many years, has recently taken up the man-

No. E-20 Acorn Range

ufacture of electric ranges. It now has a line of these new ranges, consisting of two low oven types and five cabinet types. It will be noted that the low oven types are the same except that one has three surface elements, whereas the other has four. The cabinet type ranges have the same number of surface elements,

ACORN RANGES.

Type. No.	Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
E1	Low	1-1500				
		1-1000	18x14x18	3-10½ in.	1000	5500
E5	Low	1-1500				
		1-1000	18x14x18	4-10½ in.	1000	6500
E10	Cabinet	1-1500				
		1-1000	18x14x18	4-10½ in.	1000	
	Plate warmer		18x10x18			6500
E20	Cabinet	1-1500				
		1-1000	18x14x18	4-10½ in.	1000	
		1-1500	18x10x18			8000
E30	Cabinet	1-1500				
		1-1000	18x14x18	4-10½ in.	1000	
		1-1500	18x10x18			
	Plate warmer		18x10x18			8000
E40	Cabinet	1-1500				
		1-1000	18x14x18			
	Plate warmer		18x10x18	4-10½ in.	1000	6500
E50	Cabinet	1-1500				
		1-1000	18x14x18	4-10½ in.	1000	
	Warmer		18x10x18			
	Plate shelf		18x10x18			6500

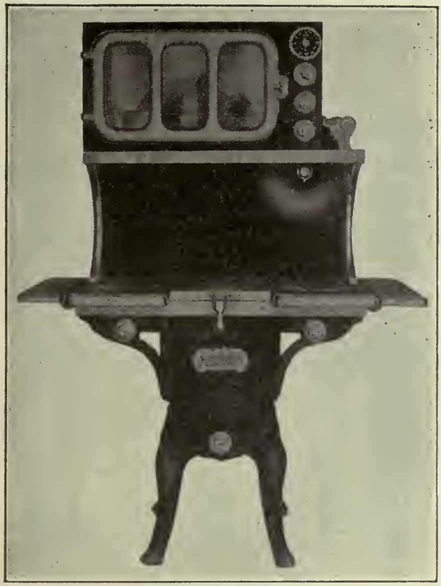
the same dimension and capacity baking and warming ovens, and occupy the same floor areas. The frames are made of cast iron and the sheet metal parts of heavy gauge iron. They are finished plain or equipped with white enameled splashers and nickel trimmings.

The ovens are lined with a special heat insulating material known as "duro-therm." They are provided with white enameled doors and broiler pans. The doors are also equipped with thermometers and positive tight closing latches.

The heating elements of the cooking surfaces are the standard General Electric sheathed wire enclosed types, whereas the oven units are the sheathed wire radiant types. Two hundred watt vegetable cookers may be substituted for any one of the surface cooking elements.

Standard Ranges.—The Standard Electric Stove Company, successors to the Detroit Fireless Stove Company, has developed a line of electric ranges which is different from other makes in several particulars. The ranges are made of Armco iron, finished in blue enamel, and nickel trimmed. The ovens and cooker pots are thoroughly insulated with rock wool, and lined with aluminum.

The compartments are mounted with the covers even with the cooking surface. These covers are hinged at the back and provided with locking devices. The compartments and surface heating elements are



Standard No. 500 Range.

mounted side by side in a line parallel with the front of the stove. The ovens are mounted above the cooking surface and fitted with plate glass doors.

The oven elements are of the radiant type. The compartment and surface heating elements are of the

STANDARD RANGES.

No.	Type Style.	—Oven— Wattage.	Dimensions.	Cooking No. of Elements.	Surface. Wattage (of Each)	Total Wattage of Range.
300	Low cooker	1-660	cooker	2	1000	2660
400	Low cooker	2-660	cooker	2	1000	3320
500	High oven	2-800	11x12x16½	2	1000	
	Low cooker	1-660	cooker			4260
501	High oven	2-1000	11x12x19	2	1000	
	Low cooker	1-660	cooker			4660
600	High oven	2-800	11x12x16½	2	1000	
	Low cookers	2-660	cookers			4920
601	High oven	2-1000	11x12x19	2	1000	
	Low cookers	2-660	cookers			5320

enclosed type, consisting of resistance wires, baked in a special cement composition which is backed up with an iron shell.

The high oven types are provided with an automatic device which may be set to turn the current off after the food has cooked a certain length of time. Control switches and pilot lamps, mounted on the frame of the ranges, are also desirable features.

Garland No. 26 Range.

Garland Ranges.—The Michigan Stove Company, one of the larger manufacturers of fuel stoves has recently placed a new line of electric ranges on the market which are somewhat different from other makes of electric stoves. They are made up by various combinations of interchangeable parts in much the same way as sectional book cases. The cast iron frame and sheet steel parts are coated with black enamel, and the bright parts are nickeled. Doors, broiler pans, and splashers are also white enameled.

The heating elements consist of resistance ribbons, wound on mica cores, and incased in sheet steel covers, forming flat strips or bars ⅞ in. in width. Six of these strips, each of 200 watts capacity, are mounted

side by side to form a heating unit. These units or grids are separately fused and located on top of hinged plates. The cooking tops are built with either two or three grids. The special indicator switches which are mounted on the grids are very desirable as their positions may be determined at a glance.

The oven is of a single standard size and may be used alone, or made a part of several combinations with the grid tops. The aluminized steel inner wall is surrounded with an inch air space, which is in turn insulated with an inch of special material. The double door is made up in much the same way as the oven walls and is provided with a tight latch. Broiling is performed in the oven by placing the meat on adjustable pans, which press it against wire bars below the grids.

GARLAND RANGES.

No.	Type. Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
21	Low	2-1200	18x12x12	2	1200	4800
23	Low	2-1200	18x12x12	4	1200	7200
25	2-Low	4-1200	18x12x12	6	1200	12000
26	Cabinet	2-1200	18x12x12	2	1200	4800
27	High	2-1200	18x12x12	2	1200	4800
28	Low	2-1200	18x12x12	4	1200	7200
31	Low	2-1200	18x12x12	3	1200	6000
33	Low	2-1200	18x12x12	6	1200	9600
36	Cabinet	2-1200	18x12x12	3	1200	6000

Hotpoint Ranges.—After many years successful experience in the production and marketing of lamp socket heating devices the Hotpoint Electric Heating Company has extended its efforts to the construction of electric ranges. The five types of ranges now manufactured are made of cast iron and sheet steel. They are attractively designed and trimmed in nickel and white enamel.

The ovens are heavily insulated with mineral wool. The doors latch tightly and may be fitted with glass if desired. The lining of the ovens is made of aluminized steel.

The cooking surfaces are hinged at the back, thus permitting easy access for inspection or repairs. The

heating elements are of the open coil radiant type, mounted above polished concave reflectors which collect the heat rays passing downward and direct them backward against the utensils. The reflectors are mounted on the crumb trays below the cooking surfaces, and may be easily removed for cleaning.

HOTPOINT RANGES.

No.	Type. Style.	Oven Wattage.	Oven Dimensions.	Cooking Surface. No. of Elements.	Cooking Surface. Wattage (of Each)	Total Wattage of Range.
D	Cabinet	2-1200	18½x18½x12	1	1500	
			*18½x18x10	1	1200	
				2	800	6,700
E	Cabinet	2-1000	16½x16½x11½	1	1500	
			*12½x12½x10½	1	1200	
				1	800	5,500
F	High oven	2-1000	18½x16½x11½	1	1500	
				1	1200	
				1	800	5,500
G	Low oven	2-1000	18½x16x11½	1	1500	
				1	1200	
				1	800	5,500
H	Low oven	2-1000	16x14x12	1	1500	
				1	800	4,300

*Warming closets.

No. E Hot Point Range.

Other Types of Ranges.—The recent rapid development of the electric range market has served to arouse latent interest in their production. A number of manufacturers of electric heating devices and fuel

ranges have signified their intention of designing and marketing electric ranges in the near future. The effort that is being put forth by the central stations and manufacturers to popularize and create a market for electric ranges must result in improved apparatus, standardization of design and eventual lowering of production costs.

CHAPTER VI

COMMERCIAL COOKING.

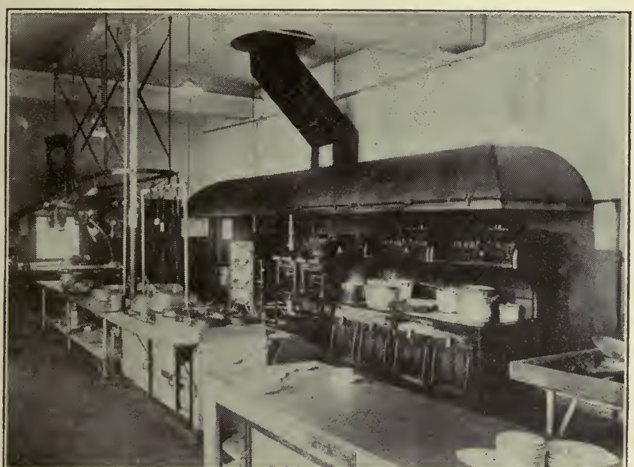
Opportunities in Hotels and Restaurants.—The substitution of electric for fuel heating apparatus in hotels, restaurants and institutions presents enormous commercial possibilities. Consideration of the opportunities afforded the central station companies, and the manufacturers of heating devices, however, have only recently been given favorable attention. The savings and other advantages accruing to the customer, the tremendous possibilities for building up attractive central station loads, and the ever widening market for the various kinds of electric heating devices in the modern hotels and restaurants, make the subject one of mutual interest worthy of serious consideration.

Advantages of Electric Cooking.—Most of the advantages already cited in favor of electric ranges in the home, apply to the use of electric cooking equipment in commercial enterprises to an even greater extent. The absence of dirt, smoke, excessive heat, and poisonous fumes, the advertising value of the clean sanitary kitchen, the improvement of food, and the saving in floor space, fuel storage capacity, and meat shrinkage, are all points of superiority that create keen interest.

Careful Planning Essential.—In spite of the advantages of electric cooking service in the modern hotel and restaurant kitchen, many failures have occurred. These have frequently been due to unwise selection of apparatus, lack of appreciation of the users' requirements, or the adverse attitude of a cook or chef. A careful preliminary study of each individual condition is of extreme importance if success is to be achieved.

It is first necessary to know the approximate maximum amount and kinds of food that will be served, how long a period will be allowed in which to serve them, how long they must be kept warm, etc. It is always necessary to consider maximum conditions. Unlike fuel apparatus electric equipment cannot be forced under conditions of stress.

The attitude, intelligence, and often the nationality of the cooks who actually operate the apparatus is worthy of serious consideration. The care and skill with which electric devices are manipulated, have



General Electric Ranges and Broilers in Bethlehem (Pa.) Steel Company's Kitchen.

much to do with their successful operation. Many cooks trained by long experience in the actual preparation of food, dislike to take up new methods. Others are intellectually unfitted or flatly refuse to learn.

Choice of Apparatus.—In laying out an installation it must be remembered that the equipment will be subjected to extremely rough usage. Only the best and most substantial apparatus available should be installed. It should be designed for easy control. The cooking surface of the range should be of adequate capacity because much top cooking is done in the

average hotel or restaurant. A few extra capacity units for rapid work are usually required. Preliminary advice, as to the kind of utensils that will give the quickest and most efficient results, will also be helpful to the user.

Shrinkage in Meats.—The tendency to minimize the importance of meat shrinkage by the management of hotels and restaurants is very general, but nevertheless such losses are worthy of serious consideration. The enormous waste resulting from the ordinary fuel methods of preparing meats, coupled with its high

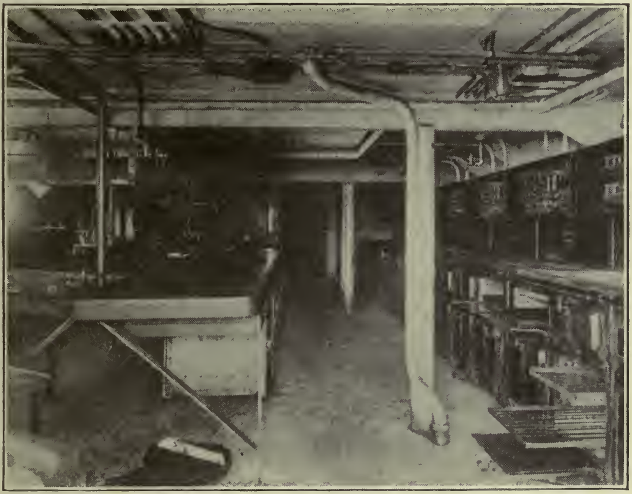
Special Hughes Cooking Surface and Standard Meat Roasting Oven in Cafeteria, Sacramento, Cal.

cost and serving value, make the savings effected by the application of electrical methods of real importance, especially where large quantities of meat are cooked daily.

To those who have actually observed meats prepared by both fuel and electric means the saving is obvious. A great many actual tests have been made, and universally the results have shown a marked saving in favor of electricity. The following table is a

compilation of experiments made by Mr. K. B. Matthews of England in the preparation of beef and mutton with coal, gas, and electricity:

	Weight before cooking. lb.	oz.	Weight after cooking. lb.	oz.	Type of Oven	Loss of weight. lb.	oz.	Loss per cent.
Ribs of beef	5	7	3	12	Coal	1	11	31.0
Leg of mutton	8	8	5	13	Coal	2	11	31.7
Shoulder of mutton	6	13	5	1	Coal	1	12	25.7
Leg of mutton	8	4	6	0	Gas	2	4	28.1
Leg of mutton	9	0	7	12	Elec.	1	4	13.1
Shoulder of mutton	4	12	4	2	Elec.	0	10	13.1
Ribs of beef	9	1	7	6	Elec.	1	11	18.6
Leg of mutton	9	1	7	10	Elec.	1	7	15.8
Shoulder of mutton	5	10	5	0	Elec.	0	10	11.1



General Electric Ranges in Galley of U. S. S. Texas.

Apparatus Available.—Only a few manufacturers of electric heating devices in this country have undertaken the extensive production of commercial cooking apparatus. There are several reasons for this condition. Development work is expensive and the market for the equipment has, until recently been limited. Only such apparatus as will "stand up" under the severest kind of operating conditions ever proves satisfactory. The rather sad experience, which some concerns have had in attempting to utilize the less rugged

types of domestic cooking devices for hotel and restaurant service, has exerted a somewhat discouraging effect on further development.

There is no doubt, however, but that the experience gained thus far, has been valuable. The types of apparatus that have stood the test have been extremely satisfactory to the users, and now that so many improvements have been made in the design of heating apparatus, there is no question but the market will develop rapidly and result in quantity production and further price reduction.

General Electric Type D-54 Range in Dietary Kitchen in Pennsylvania State Hospital, Philadelphia, Pa.

As quite a few types of apparatus designed exclusively for commercial cooking service are now available, some of the features of those best known will be described.

Hotel Ranges.—No other piece of kitchen equipment is subject to such severe treatment as the hotel or restaurant range, especially the top cooking surface. Earlier installations were either too frail, too small, or too slow in heating to give satisfaction. The modern types, however, are heavily constructed,

available in adequate capacities, and generally provided with sufficient wattage in the heating units to perform work quickly.

General Electric Hotel Range.—This type of range is constructed of heavy cast iron, and steel sheet metal. The oven walls are well insulated with navy firefelt. The cooking surfaces are composed of eight oblong 9¼ by 12 in. enclosed type cast iron heating units, placed side by side, arranged with four 1600 watt units in front for high temperature cooking, and with four 800 watt units in back for lower temperature work.

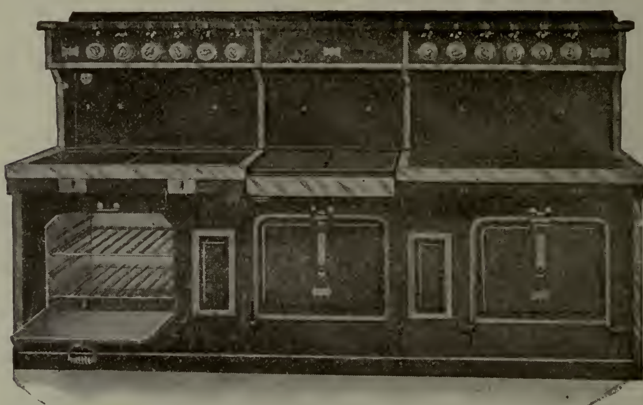
There are two ovens, each having a capacity of 4800 watts, and inside dimensions of 18 in. width, 28 in. depth and 16 in. height. The doors are heavily constructed and are of the drop type. All the heating units are fused and controlled by knife switches located in a sheet metal compartment above and at the rear of the cooking surface.

The overall dimensions of the range are width 44 in., depth 38 in. and height to top of switch box 68 in. The maximum rated capacity is 19.2 kilowatts. An equipment sufficiently large to take care of any requirements can be provided by placing as many of these ranges side by side as are necessary.

Simplex Hotel Ranges.—The high duty ranges manufactured for hotel and restaurant service are made of much heavier materials than those designed for domestic use. The parts are constructed of heavy gauge steel and cast iron. The general appearance is much the same as that of the more elaborate hotel fuel ranges. They are ordinarily made up in complete sections consisting of a cooking surface 7 ft. 6 in. long by 2 ft. 9 in. wide, with two ovens mounted beneath. For very large installations, two or more of these sections are placed, end to end, or back to back.

The cooking surface is usually made up to suit the customer's requirements. The units may consist of any suitable arrangement of the following heating elements in various capacities:

Rim or flat griddles, 9 in. by 12 in., 12 in. by 18 in. or 18 in. by 24 in. sizes.
Hotel broilers, 9 in. by 12 in., or 12 in. by 18 in. sizes.
Disc stoves 4½ in. diameters to 20 in. diameters together with special heavy copper kettles and other utensils of similar dimensions.
Deep fat frying kettles—12 in. diameter, 5 in. deep.
Hotel toasters—10 in. by 12 in., or 12 in. by 18 in. sizes.
Waffle irons—two or three section (for 4½ in. waffles.)



Simplex 3-Oven Range, Welfare Dining Hall, Edison Electric Illuminating Company, Boston.

The ovens are of heavy construction, well insulated and provided with massive drop doors. The

Four-Section Simplex Range, Montana State Hospital, Billings.

interior dimensions are 24 in. wide, 27 in. deep, and 16 in. high. The oven heaters are located in both the top and bottom.

Each range section is supplied with a distributing panel, located between the ovens and accessible from the front. The circuits are separately fused, and each device has its own control switch, and pilot light.

Meat Broilers.—Two types of broilers are made—the open type and the enclosed type. It is safe to

Hughes Meat Broiler.

say that better results can be secured with either of these types than are attainable with any kind of fuel broiler.

The Simplex open type apparatus consists of a corrugated cast iron surface slanting slightly towards

a grooved end. The meat rests on the hot surface and the juices are collected at the mouth of the groove and poured over the meat before serving. The heating is done by means of a sealed-in unit under the corrugated surface. The standard hotel size is 12 in. by 18 in. and has a capacity of 2200 watts.

The Hughes Broiler is of the enclosed type and is manufactured in three standard sizes. The smaller size has interior dimensions of 18 in. by 30 in. by 8 in. and has a capacity of 4.5 kilowatts. The medium size is composed of two compartments placed side by side, each having the same dimensions and capacity. The large size is 32 in. by 30 in. by 8 in. and has a capacity of 10 kilowatts. The walls of these broilers are heavily insulated. The units are of the open type and give off radiant heat. The exteriors are finished in black iron, and the bodies are supported on angle iron frames.

The General Electric broiler is of the enclosed type and equipped with radiant heating elements. The

General Electric Meat Broiler.

broiling area is 14 in. by 20 in. The rated capacity is 5 kilowatts, of which 4.5 kilowatts is used during actual operation and 500 watts for maintaining the temperature when the device is not in service. It is

made of heavy sheet steel and angle iron construction and the walls are thoroughly insulated. It is mounted on angle iron supports.

Hot Closets.—Hot closets are required in almost every hotel and restaurant kitchen for keeping food and dishes warm. They generally consist of double walled or well-insulated ovens with oue or more shelves, doors opening to the side, and equipped with

Cutler-Hammer Hot Closet.

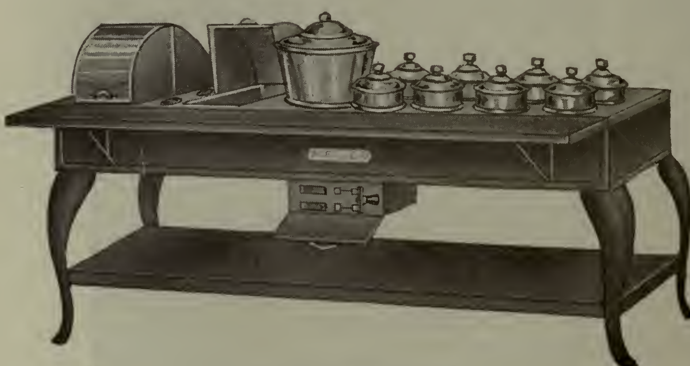
relatively small heating units mounted in the bottom. They are usually provided with three-heat control switches. The Hughes and Simplex warming ovens are made up in several standard sizes but may be designed in any special size or capacity.

Steam Tables.—When food must be kept warm for any length of time for serving, a steam table is usually considered a necessity. Either immersion or circulation heaters may be used for this purpose.

Immersion heaters may be inserted through the top or in the side of the steam table. They must be

kept covered with water constantly, or the elements will burn out.

Circulation heaters of various types may be utilized in heating a steam table by connecting them with pipes to the bottom of the tank and placing the heaters at an angle of about 10° to 15° with the horizontal. The colder water reaching the lower end of the heater will rise in temperature and gradually pass up through the heater into the tank, thus creating a constant circulation and gradual heating of water as long as the current is applied.



"Neuco" Steam Table.

It is essential that steam tables be well insulated against heat losses. If the circulation method of heating is employed, the pipes leading to and away from the heater should be well lagged.

In making calculations of the heater capacity required for a steam table, area of radiating surface, kind and thickness of lagging, nature of top surface, amount of water in reservoir, hours of use, and the maximum quantity of food warmed, should be taken into consideration.

Water Heaters.—A supply of hot water for cooking, dish washing and various other purposes must always be provided in the hotel or restaurant kitchen. The subject of heating water electrically is taken up

more fully in another chapter, but it is well to keep in mind that the demand for hot water is usually much in excess of most chefs' or cooks' preliminary estimates.

Frying Kettles.—Fat, oil, or lard is often required to be heated to a high temperature for preparing French fried potatoes, doughnuts, croquettes, and other foods.

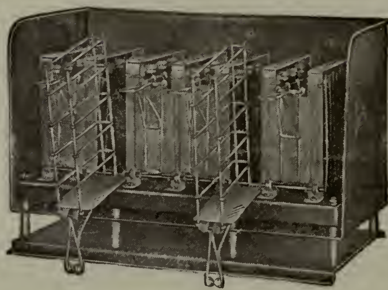
The Simplex frying kettle designed for heavy service has standard dimensions of 12-inch diameter and 5-inch depth. It has a maximum rated capacity

Simplex Frying Kettle.

of 2400 watts and is provided with a three-heat control switch. Larger sizes are sometimes manufactured for special work.

Toasters.—Some provision for toasting bread evenly and quickly is required in all hotel and restaurant kitchens. A high heat is required and the device must do the work rapidly, or the toast will be dry and hard.

The General Electric radiant type toaster has a capacity of two, three, or six slices of toast, during the preparation of which 1350 watts, 1800 watts, and



General Electric Hotel Toaster.

3150 watts, respectively are connected. The sides, base, and back of the device are of sheet iron. The top and front are open. The heating coils, of which there are seven, are placed at each end and between the hinged wire racks that support the slices of bread. Each rack is separately hinged to facilitate the removel

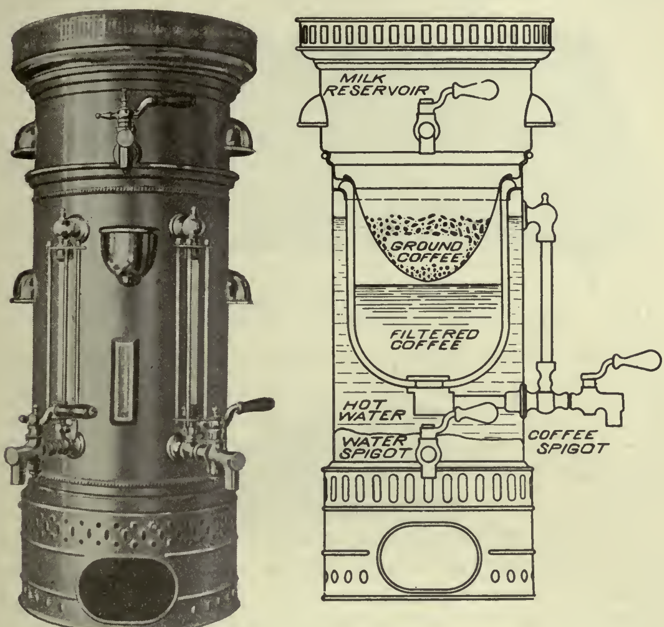
Hughes Hotel Toaster.

or examination of individual slices.

The Hughes toaster is of the oven type. The toast is placed on a rack measuring 8 inches by 18½ inches and inserted within the sheet iron casing between radiant type heating elements. The rated

capacity is 2 kilowatts. The outside dimensions of the device are 9¼ inches wide, 19 inches deep, and 9 inches high. Sixteen slices of bread may be toasted at one time. As the operation is performed within the casing the heat is conserved to a marked extent.

The Simplex toaster consists of an oblong flat top griddle on which the bread is placed and provided with either one or two grids, hinged at the back, which are folded down upon the upper surface of the bread,



Cutler-Hammer Coffee Urn.

thereby toasting both sides of the slices simultaneously. The device is made in two sizes. The smaller one is 10 inches by 12 inches and has a rated capacity of 1000 watts. The larger one is 12 inches by 18 inches and is rated at 1700 watts. Both sizes are equipped with three-heat switches and so connected that the bottom griddle may be heated separately for baking hot cakes and similar operations. The heating elements are of the enclosed sealed-in type.

Coffee Urns.—Either immersion type or disc type elements may be used for heating coffee urns in a hotel or restaurant. Electrically heated urns of ten gallons capacity or larger, provided with heating units of either the immersion or disc type, are available. Some of these urns are of the single shell type, whereas others are double walled and thoroughly insulated. Some are of the spray type and others are equipped with stoneware crocks for holding the coffee.

Simplex Hot Cake Griddle.

The rated capacities of the standard single shell type urns vary from about 1200 watts for a two gallon size, to about 4500 watts for the ten gallon size. The double walled types are much to be preferred, however, on account of their higher operating efficiencies.

It is often desirable to convert a fuel burning urn into an electrically heated device. This may be done, either by inserting an immersion heater of the proper design in the top, or by supporting a heating element against the bottom of the urn.

Hot Cake and Frying Gridldes.—Flat top griddles for making hot cakes are available in many sizes and makes. The 18 inch by 24 inch Simplex flat top griddle has a rated capacity of 2800 watts, whereas the frying griddle of the same make has a rated capacity of 3300 watts.

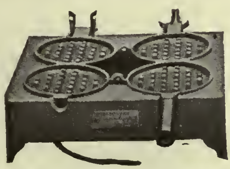
Frying griddles are a necessary adjunct to the modern hotel and restaurant kitchen. They are usually provided with raised edges. For quick frying

of eggs, steaks, and fish orders they are convenient. Operated on medium heat, the frying griddles may be used for making hot cakes.

Simplex Frying Griddle.

Waffle Irons.—For making waffles the electrically heated device is much superior to those heated by fuel. Little grease is required. The waffles are evenly browned and very attractive and palatable.

The Simplex waffle irons are made in two sizes, adaptable for making either two or three 4½ in. waffles at a time, and of rated capacities of 770 watts and 1150 watts respectively. They are so designed



Simplex Two-Section Waffle Iron.

that the sections are connected in series when heating up and in parallel when the waffles are baking. This arrangement makes it possible to keep the elements moderately hot between operations, and very hot while the waffles are cooking. The elements are of the sealed-in type imbedded in the iron. The frame of the device is of heavy cast iron.

Electric Bake Ovens.

Extent of Use.—The electric bake oven is being used extensively and with marked success in a number of western cities and towns as well as in some

parts of the east. It combines efficiency, speed, economy, and durability. It has found widest application in small bakeries, hotels, restaurants, and various institutions. The electric bake oven is a comparatively new development, and its possibilities have but recently been realized. There is no doubt, but what it has a wide field of usefulness, and will eventually afford a desirable load for central stations throughout the country.

Construction of Electric Ovens.—Electric ovens are usually constructed in the cabinet form, with from three to five decks or compartments built one above the other. This design is unlike the brick baker's oven which has only one deck but is somewhat similar to the ordinary portable gas oven. The exterior walls are generally made up of galvanized sheet iron and the space between the exterior and interior walls filled with a thick layer of mineral wool or some other heat resisting material.

The capacities of ovens now in use vary from 30 to 500 one-pound loaves, with baking surfaces of from 10 to 160 square feet, and with heater capacities of from 4 to 65 kilowatts. The weights of these ovens vary from 700 to 10,000 pounds. They may usually be heated to the proper temperature for bread baking in from 40 to 60 minutes.

There are two common methods of heating electric ovens, both of which have certain advantages. In the styles first placed on the market, the heating elements were mounted below the lower deck, and the heat circulated upwards along the sides and interior walls which were so arranged as to properly distribute the heat at each deck. The General Electric and Simplex ovens are made in this way. The Hughes bake oven, however, is heated by coils of resistance wire mounted between each deck, above the top deck, and below the bottom deck. Each element is controlled by a three-heat switch. The wattage of each element is a little greater than the one above it, and likewise, the front part of each deck is made somewhat hotter than the back. These provisions are

necessary on account of the gradual rise of heat to the top, and because of the heat losses around the deck doors.

Features of Electric Ovens.—The decks are accessible through hinged drop doors. The standard height of deck is about eight inches but they may be made higher if necessary. Tile decks may be used for continuous or heavy baking. Ovens so equipped will require more time to heat up but will maintain the temperature to better advantage when they are finally heated. Ovens not provided with tile decks are usually furnished with drip pans.

An accurate pyrometer for indicating the temperature should always be made a part of the oven equipment. This instrument will be an aid to economy of operation and a great convenience for the baker.

Table I.—Simplex Bake Ovens.

No.	No. 1-lb. Loaves.	No. of Decks.	Sq. ft. of Baking Surface.	Height of Decks in Inches.	Maximum kw. Demand.
152	36	3	12	8	6
154	56	4	18	8	8
156	70	5	23	8	9
158	90	5	26	8	10

Simplex No. 156 Bake Oven.

Simplex Ovens.—Four standard sized ovens, as shown in Table I, are made by the Simplex Company. The temperatures in the ovens are controlled by single

three-heat switches, which are usually fastened to the wall. The heating elements are of the cast grid type mounted in the base.

General Electric Ovens.—Three standard ovens, as shown in Table II, are manufactured by the General Electric Company. They are of the Blodgett type,

General Electric Type D-46 Bake Oven.

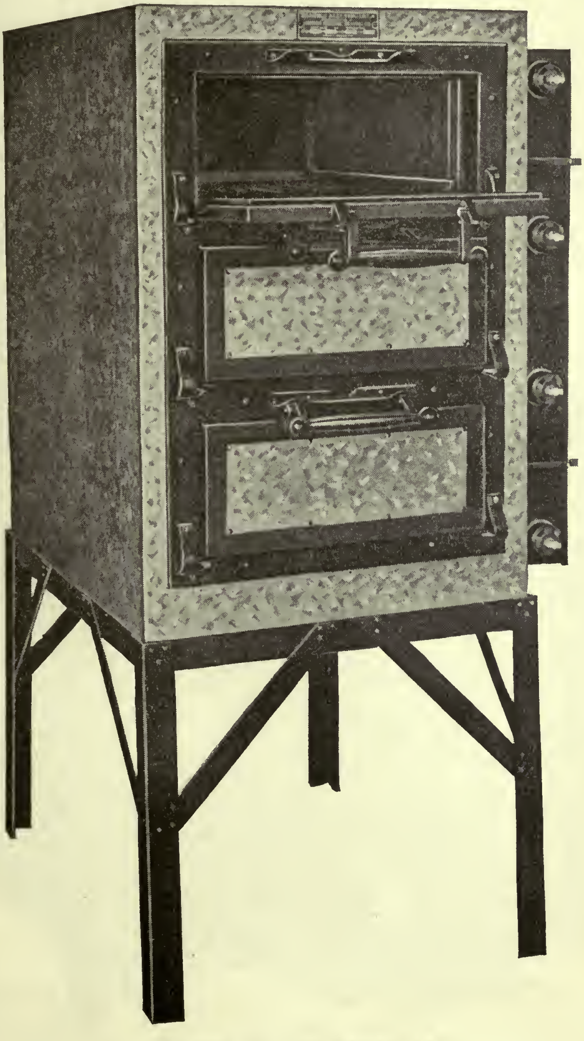
with grid resistance heating units fitted into the base. The temperature is controlled by a three-heat knife switch, which may be mounted in any convenient position.

Table II.—General Electric Bake Ovens.

Type.	No. 1½-lb. Loaves.	No. of Decks.	Sq. ft of Baking Surface.	Dimensions of Baking Comp. in Inches. Width.	Depth.	Height.	Maximum kw. Demand.
D-44	30	3	11.74	28	20	6.75	6
D-46	56	4	21.11	38	20	6.75	9
D-47	84	4	31.66	38	30	6.75	13

Hughes Ovens.—Ten standard ovens, as shown in Table III, are made by the Hughes Company. The heating units are mounted between the decks, and each

set is controlled by a separate three-heat switch. These ovens may be manufactured for use with tile decks when desired.



Hughes No. 200 Bake Oven.

Table III.—Hughes Bake Ovens.

Cat. No.	No. 1-lb. Loaves.	No. of Depth.	Sq. ft of Baking Surface.	Dimensions of Baking Comp. in Inches. Width.	Depth.	Height.	Maximum kw. Demand.
150	30	3	10	18	27	8	4
175	40	4	13.5	18	27	8	5
200	63	3	20.75	37	27	8	7.3
215	84	4	27.75	37	27	8	10
220	126	3	41	37	53	8	15
250	168	4	54.5	37	53	8	20
300	192	3	61.5	37	80	8	23.5
315	252	4	82	37	80	8	31
400	378	3	121	73	80	8	47
415	504	4	161	73	80	8	62

Advantages of Electric Ovens.—The many features of superiority of electric heat over fuel heat which apply in the use of electric ranges obviously attend its use in connection with electric baking ovens. A baker's shop is ordinarily a hot, stuffy place because

"Neuco" No. 107 Bake Oven (Capacity 48 2-lb. Loaves).

of the intense heat. Very little radiation of heat, however, is noticeable from the electric oven on account of its heavy insulation. The hand may be held against the outside with no discomfort after the oven has been in service several hours.

Heat Regulation.—The heat regulation in an electric oven is nearly perfect. It is an obvious advantage

Hughes No. 300 Bake Oven, Installed in Bakery and Grocery, Norfolk, Va.

to be able to obtain the desired temperature in an oven in a short period of time. This feature alone goes a long way toward insuring satisfactory results.

With coal ovens it is necessary to have a continuous fire in order that they may be put in operation without delay. Sometimes only one or two batches of bread are baked during the night but the fire must be kept up to take care of the next day's business. The electric oven overcomes this objection as it can be heated quickly. If the oven is not used continuously it may be maintained at baking temperature on the low heat with one-quarter the maximum current consumption.

Saving in Floor Space.—Only a fraction of the floor space is required for an electric oven that is necessary for a brick oven. The user of a brick oven, furthermore, must have a large space in front of his oven in which to manipulate his peel for inserting and removing material. Very small space for this purpose is required by the user of an electric oven. The use of coal ovens, moreover, makes it necessary to provide storage space for a large supply of fuel. Coal must also be paid for in advance and a considerable

Hughes 500-Loaf Oven (Special Design).

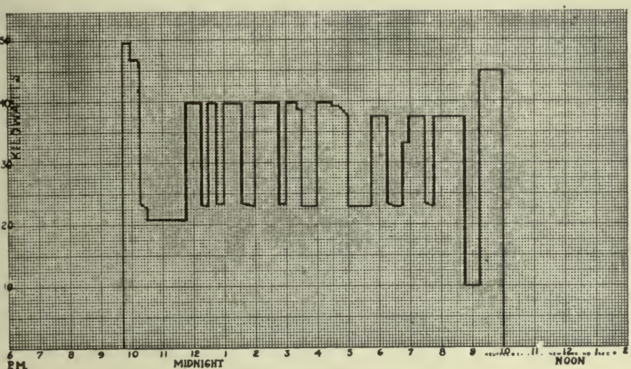
amount of money is tied up. No storage space, however, is required for electric energy, and it is not paid for until used.

When a new bakery is constructed it may be made of lighter material, because electric ovens weigh only a fraction as much as brick ovens.

Sanitary Features of Electric Ovens.—Electric ovens are absolutely sanitary. The heat is derived from resistances operating at comparatively low temperatures. There are no fumes or objectionable odors such as are produced by gas ovens, to contend with. The dirt and dust always encountered with brick ovens are entirely obviated. The electric ovens may also be easily and quickly cleaned.

The fact that an electric oven is used in a place of business is an advertisement for the establishment. It carries an appeal to the public generally.

Diversity of Baking.—All classes and kinds of bread, cake, cookies, pies, pie shells, patty shells, and rolls may be baked in the electric oven with the greatest satisfaction and ease, and at a very reasonable cost. Patty shells will attain the beautiful brown and flaky appearance in an electric oven without the use of egg



Typical Load Curve Hughes Special 500-Loaf Oven, Turning Out 560 14½-oz. Loaves Every 45 Minutes.

and butter mixtures that are usually required in other ovens. Bread, cake and pies will always have just the right shape and color. They will likewise remain fresh longer, as less moisture is removed from the product.

A larger, better colored, finer textured, and thinner crusted loaf of bread can be produced in the electric, than in the fuel oven. The light golden brown color of bread baked electrically will always increase the demand for the product.

Cakes, cookies, etc., which require lower temperatures than bread, can be baked after the bread is taken from the oven without using additional current, or they may be baked while the oven is heating up.

Economy in Roasting Meats.—The great variety of food that may be prepared in an electric oven, makes

it of considerable value for cafe, cafeteria, hotel, and restaurant use. All kinds of meats, including fish and fowl, may be roasted in an electric oven with less shrinkage than in any type of fuel oven. The shrinkage loss in fuel ovens varies from 30 to 40 per cent, whereas it is only from 15 to 20 per cent in the electric oven. The meats will always be juicy, wholesome, clean, attractive, and delicious in flavor. No oxygen being consumed or poisonous gases being given off in the electric oven, the meats do not take on the hard, bitter tasting crust often apparent where fuel is used.

In roasting chickens in the electric oven it is not necessary to spread a greased cloth over them to prevent the formation of hard crusts. They will be juicy and palatable if cooked in an open pan.

Utilizing Stored Heat.—After the day's cooking is done, cereal, baked apples, baked pork and beans, spiced ham, etc., can be prepared in electric ovens without using any additional current. Simply place the materials in the oven. They will cook on the stored heat and be ready to serve for breakfast.

CHAPTER VII

ELECTRIC WATER HEATING.

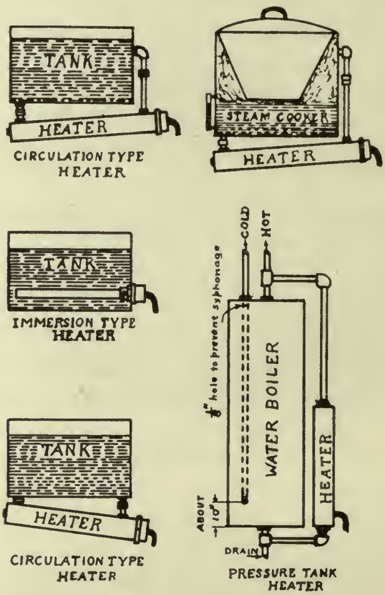
Hot Water a Necessity.—Enormous quantities of energy are constantly required for heating water. In the average home, more energy is used for heating water than for any other domestic purpose aside from that utilized in warming the air. In the industrial field, the operations that require hot water are almost without number.

For generations the only way of heating water has been by fuel combustion methods whereby chemical energy stored in fuel is transformed into heat energy, which is in turn taken up by the water in amounts varying with the efficiency of the apparatus employed.

Comparison of Fuel and Electricity.—As set forth in another chapter, most fuels, on the basis of actual cost of the two mediums, have a higher heating value than electricity. It is possible, however, to operate an electric water heater at a much higher efficiency than a fuel heater. If necessary, the electric heater may be immersed in the liquid itself, in which case practically all the heat generated must be imparted directly to the water. This is impossible with a fuel device which requires that external heat be applied. It is obvious that fuel heat generated on the outside of a tank must lose much useful energy through the chimney and the surrounding atmosphere.

Although it should not be understood that electricity for heating water can compete on a cost basis with the many cheap fuels that are available in most localities, it should be known that it is often possible to so design electrical installations that they will not be more expensive to operate than the less efficient fuel burning devices that are commonly used. This condition is especially true with the smaller installations.

In making comparisons between fuel and electric water heating methods, the many advantages of electric operation, aside from the cost, should be considered. Dirt, smoke, moisture, fumes, and excessive heat are obviated when the electric method is used. The dangers of fire and explosions are done away with. The care and attention required by fuel burning appa-



Typical Methods for Heating Water.

ratus is eliminated and the only attention necessary is the turning on and off of the current. Some of the electric devices now being constructed are controlled automatically, and therefore demand no attention whatever.

Thermal Characteristics of Water.—No other known liquid or solid has as high a specific heat as water. In other words, water has a greater capacity for storing heat energy than an equal weight of any liquid or solid raised an equal number of degrees in temperature. Its capacity for storing heat may be

considered analogous to that of a sponge for absorbing water.

After the boiling point of water is reached, steam begins to be generated and unless the water is heated under pressure, it no longer continues to store energy, but gives off the heat with the same rapidity it is taken up.

Water, like other liquids, is heated by convection currents set up within the substance itself. Very little of the heating is done by conduction between the individual particles of which it is composed. The convection currents are created by the difference in weight of hot and cold water. Whereas, at 32° F. water weighs 62.42 pounds per cubic foot, it only weighs 59.85 pounds at 212° F. It is this difference in weight that causes the top of a storage tank to become hot before the bottom, and which creates the circulation in the ordinary hot water heating system.

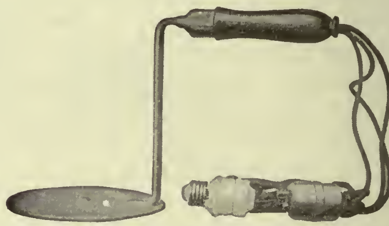
Cutler-Hammer Instantaneous Water Heater.

Electric Energy Required for Heating Water—Assuming the weight of water to be 8.3356 pounds per gallon it may be calculated that one kilowatt hour of electric energy will raise 409.33 gallons of water one degree F. or 4.0933 gallons 100° F. If a water heater of one kilowatt capacity be operated at 100 per cent efficiency it would accomplish the following results:

Raise	409.33 gal.	1° F.	in	1 hour	and	consume	1	kw.-hr.
Raise	8.19 gal.	50° F.	in	1 hour	and	consume	1	kw.-hr.
Raise	4.09 gal.	100° F.	in	1 hour	and	consume	1	kw.-hr.
Raise	9823.9 gal.	1° F.	in	24 hours	and	consume	24	kw.-hr.
Raise	196.48 gal.	50° F.	in	24 hours	and	consume	24	kw.-hr.
Raise	98.24 gal.	100° F.	in	24 hours	and	consume	24	kw.-hr.

For ordinary calculations, it is often convenient to remember that one kilowatt of capacity will raise about 100 gallons of water 100° F. in twenty-four hours.

Simplex Coil Type Immersion Heaters.



Westinghouse Disc Type Immersion Heater.

Utilizing Waste Energy.—The energy utilized in heating water is expended in two ways. A certain percentage is required to supply the losses of heat which take place on account of radiation, convection, and conduction from the heater, piping system, and storage tank. Energy, so expended, cannot be utilized in any other way and is entirely wasted. The balance of the heat energy generated may be called the useful energy, as it alone affords the user his supply of hot water. It is therefore apparent that every possible effort should be made to so design a water heating installation that the losses will be reduced to a minimum, and in that way utilize the waste energy. This purpose is usually accomplished by covering the pipes and tank with material of low heat conductivity—a process generally known as lagging.

Heat Losses.—Authorities vary in their estimates of heat losses from metallic surfaces, between 1.5 and 3 B.t.u. per square foot per Fahrenheit degree differ-

ence in temperature per hour. The loss is naturally greater from dark, rough radiator surfaces than from the brighter and smoother ones of galvanized iron tanks and pipes. For ordinary water heating calculations it has been found safe to figure a loss of 0.6 of a watt (approximately 2 B.t.u.) loss per square foot per Fahrenheit degree difference of temperature per hour.

The tremendous amount of heat that is lost from surfaces of exposed water tanks and piping systems is seldom appreciated. It may be assumed, for instance, that a 24 gallon tank of water having an exposed area of 14 square feet, is to be maintained at a temperature of 100° F. above that of the surrounding atmosphere. The energy that would be required to maintain such a temperature, provided no water was drawn off, would be approximately:

$$14 \times .6 \times 100 = 840 \text{ watts.}$$

If this tank were heated with a one kilowatt heater there would be but 160 watts of the total capacity available for supplying hot water at the required temperature. In this instance, the energy produced by the 840 watts of the heater capacity would be lost and only 160 watts capacity utilized.

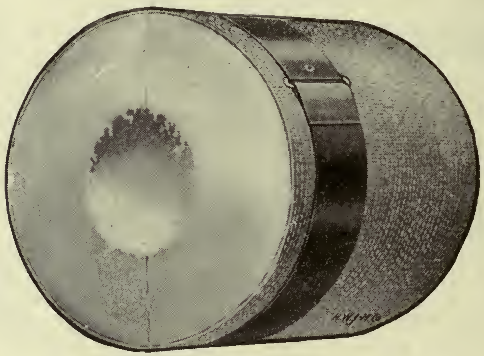
Efficient Lagging Essential.—Had this tank been covered with some form of lagging material of low heat conductivity, having an efficiency of say 85 per cent, the capacity required to maintain the desired temperature would have been:

$$14 \times .6 \times 100 \times 15\% = 126 \text{ watts.}$$

It is thus apparent that the energy produced by only 126 watts capacity could be lost, whereas, the remaining 874 watts capacity could be utilized for heating water to the required temperature. The operating efficiency of the unlagged tank installation would be 16 per cent, whereas it would be 87.4 per cent efficient when lagged in the manner assumed.

Table 1 indicates the number of gallons of water that can be delivered per day at a temperature 100° F. above that of the water supply and of the surround-

ing atmosphere with various installations. The figures are based on the use of seven different standard sized tanks and six different capacity heaters. The daily output is computed, first with the tanks unlagged, second with a 50 per cent efficient covering applied, and third with an 80 per cent efficient covering applied. Other losses than those from the surfaces of the tanks are not considered.



J. M. Magnesia Sectional Pipe Covering.

TABLE 1.

Gallons of Water per day—100° F. Temperature Rise.

Heater Capacity in Watts	Tank Dimensions and Capacities.							
	Gallons Capacity.	18	24	30	40	66	82	100
	Dimensions.......	12″x3′	21″x4′	12″x5′	14″x5′	18″x5′	20″x5′	22″x5′
	Area in Sq. Ft...	11	14	17.25	21.3	27	30.5	34
750	Unlagged	9	..	..	..	..	..	..
	Lagged 50% Eff.	42	33	23	11	..	..	..
	Lagged 80% Eff.	62	58	54	49	43	38	34
1000	Unlagged	34	16	..	..	..	..	..
	Lagged 50% Eff.	67	58	48	36	19	9	..
	Lagged 80% Eff.	88	83	79	74	68	63	59
1500	Unlagged	84	66	46	22	..	..	..
	Lagged 50% Eff.	117	108	98	86	69	58	48
	Lagged 80% Eff.	137	133	129	124	118	113	109
2000	Unlagged	...	116	97	72	38	17	..
	Lagged 50% Eff.	...	158	148	136	119	109	98
	Lagged 80% Eff.	...	183	179	174	168	163	159
3000	Unlagged	...	...	197	172	138	117	96
	Lagged 50% Eff.	...	...	248	236	219	209	198
	Lagged 80% Eff.	...	...	279	274	268	263	259
5000	Unlagged	...	...	...	372	338	317	296
	Lagged 50% Eff.	...	...	...	436	419	408	398
	Lagged 80% Eff.	...	...	...	474	468	463	459

Methods of Heating Water Electrically.—There are two general methods of heating water that have come into general use—the instantaneous method and

the thermal storage method. The former makes use of special devices which heat the water as it passes from the faucet and which are not connected at other times. The latter method, as the name implies, is used

United Sales Hot Water Faucet.

for heating water and storing it for future use in a tank or reservoir.

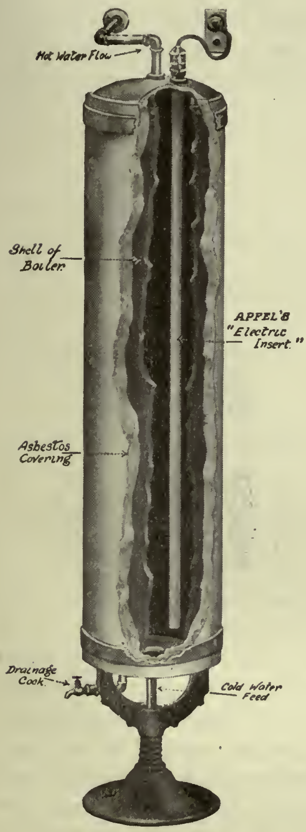
Two types of heating devices are commonly used with thermal storage systems—the immersion type, and the circulation type. The former is usually inserted in the tank, whereas the latter is connected with pipes outside the tank.

Instantaneous Water Heating.—Devices for this class of service are usually made to attach to the ordinary water faucet. They are convenient for many purposes where only small quantities of hot water are needed. As it is possible for one kilowatt to heat only about 4 gallons of water 100° F. per hour, their use is naturally somewhat limited. The load which they create is often considered undesirable on account of the high demand and relatively low energy consumption.

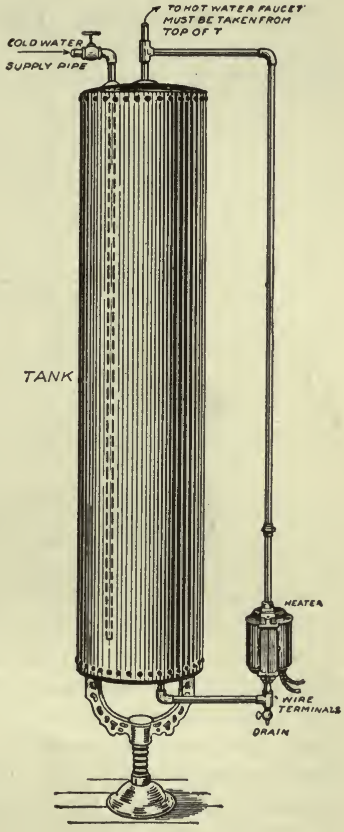
Instantaneous heaters are usually made with a resistance coil around which the water circulates, and which is connected when the faucet is opened. Another device, however, consists of a hollow cylinder and core of graphite. When the water flows around the core inside the cylinder it acts as a conductor and the flow of current set up causes heat to be generated in the water itself. In other words, the water is heated in the same way as in the common water rheostat.

Thermal Storage Water Heating.—The thermal storage method is more often employed than the instantaneous method. The equipment must consist of at least two essential parts—a water heater and a containing vessel for storing the water after it is heated. With an equipment of this kind the user may store up a large quantity of hot water slowly and draw it off as rapidly as he wishes when it becomes heated. The load created by this kind of a heater is desirable on account of its low demand and relatively high energy consumption. It is apparent, on the other hand, that such equipments are necessarily wasteful of energy unless the heat stored in the water is conserved.

Immersion Type Heaters.—The heating of water or other liquids is accomplished with these devices, by the insertion of resistance elements in them. Many types of immersion heaters have been developed. Some



Apfel Immersion Tank Heater.



Coin Circulation Tank Heater.

consist of open coils and others of hermetically sealed tubes. Some are constructed for use in open vessels, and others are provided with fittings for attaching them to closed tanks.

The essential advantage of this type of heater, for thermal storage water heating, is that the device must give off practically all its heat to the liquid. Energy can only be dissipated indirectly from the water and surface of the containing vessel or directly by conduction through the metallic fittings.

Circulation Type Heaters.—It is customary, though not essential, to mount a circulation type heater outside the tank or reservoir. A pipe leading

Westinghouse Circulation Heater.

Westinghouse Immersion Heater.

from the bottom of the containing vessel carries the colder water to the heater. As the water becomes hotter it rises through another pipe connected to the top of the containing vessel. This process continues, regardless of whether any pressure is applied, until all the water is heated.

Circulation heaters are available in many styles, forms, and sizes. The Westinghouse heater consists essentially of a waterproof bayonet element, inserted in a metal casing, and designed so that the water circulates around the heating element inside the casing. The Simplex, General Electric, and many other types of circulation heaters, are made up of resistance wire

wound around hollow tubes through which the water passes. The Coin Machine heater is of the induction type, and so designed that the passage of current through copper wires surrounding an iron core creates eddy currents in the iron and causes it to heat. The advantages of the induction type heater over the resistance types are its rugged construction and its capacity for running dry without burning out when the water supply is cut off. The present designs of induction heaters, however, create a relatively low power factor load, averaging about 80 per cent.

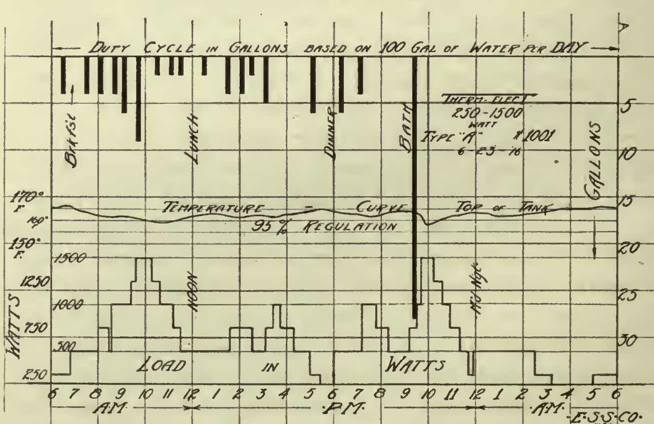
The attractive features about the circulation type heaters are the ease with which they may be attached to any tank or containing vessel, and the facility with which they may be removed for repairing or cleaning. The water, furthermore, is delivered to the top of the tank as it is heated and is soon ready for use even though only a portion of the tank may be heated when the water is wanted. The great disadvantage is the extra radiating surface the heaters and pipes present, and the additional, though relatively small, heat losses that must inevitably result.

Essential Features of a Water Heater.—A device of this character should be durable, easily removed for cleaning or repairing, and readily controlled. The surface exposed to the air should be of small area or thoroughly insulated from heat losses. The relative area of the heating surface exposed to the water should be large in proportion to the wattage of the heater. Air bubbles and deposits will inevitably collect if the heating element is operated at a high temperature. The amount of scale which forms inside the heater varies widely in different localities, and depends upon the amount of salts in solution. The scale may be chipped off or removed with a dilute solution of hydrochloric acid. In either the instantaneous or circulation type heaters, it is generally best to have the water passage quite large, so that sediment or deposits will not obstruct the flow. It is sometimes desirable to restrict the flow of water through a circulation heater in order that it may rise to a higher temperature as it

passes. This may be done by making the passageway smaller or by mounting the heater somewhat higher than the bottom of the tank. Water heaters that create low demands and are required for long hour use are generally considered more desirable load builders than those constructed for high demands and short hour use.

Automatic Temperature Control Devices.—Where it is desirable to keep a supply of hot water available for use at any and all times or to maintain water at a certain temperature for various purposes, automatic temperature control devices have a wide field of application. Electrical apparatus lends itself particularly well to automatic control, but the possibilities it naturally affords are as yet little understood. Any device of this kind that will cut off the current supply immediately a certain predetermined temperature is attained will be a wonderful convenience, and a great economizer of energy. Its general application cannot but improve the diversity factor of central station loads.

Devices of this character should be simple, durable, easily repaired, and readily adjusted.



Performance Curves Therm Elect Water Heater.
Temperature and Load Regulation, 24 hrs.

Explanation of Temperatures and Load Regulation Curves of Therm-Elect 1500-watt Water Heater.

The above curves were plotted from observations taken on the 24-hour operation of a 1500-watt thermally-controlled Therm-Elect Immersion Heater installed in a standard 30-gallon kitchen boiler.

The heavy black lines extending from the top of the chart are a graphic representation of the hot water duty-cycle imposed upon the heating system in a household using 100 gallons of 116 degree F. water per day.

The length of each line is in proportion to the gallons of water drawn at the time indicated by its position; covering the day from the preparation of breakfast at 6:30 a. m. through the bathing period from 9 to 10 p. m.

The curve in the center of the chart indicates the temperature regulation of the water drawn from the tank, and represents a regulation of 95 per cent for the immersion heater.

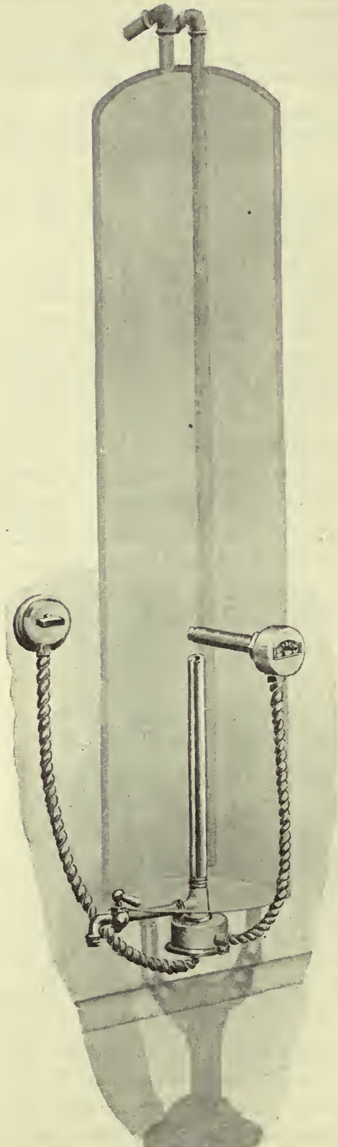
The load curve produced by the six-point thermal control is shown at the bottom of the page, with its peaks at 10 a. m., 3 p. m. and at 10 p. m., and its valleys at 6 a. m., 12 noon and 6 p. m., indicating the diversity which would be obtained with respect to a cooking load operating in combination with the thermally-controlled water-heater.

Automatic Time Control Devices.—Many companies are in position to supply energy during off peak hours at lower rates than during the period of maximum load. The building up of such loads by means of thermal storage water heating apparatus, operated with time control devices, has probably not been given the attention heretofore that it will receive in the future. The loads that could be created would prove enormous.

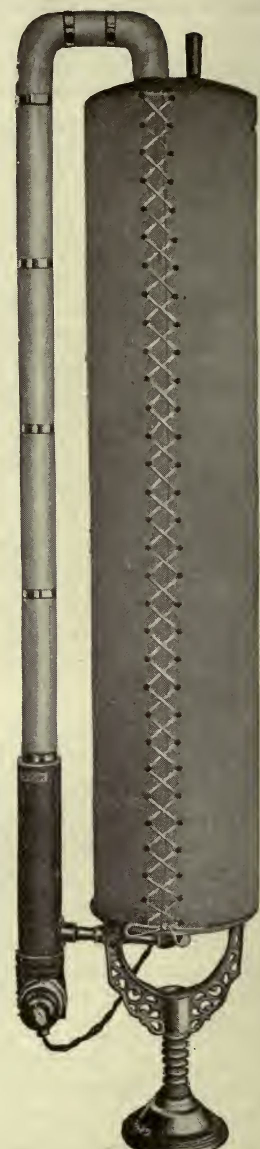
An equipment of this kind naturally requires larger water storage facilities than one that may be supplied with energy at any and all times. The additional storage necessary will depend on the number of hours during which the energy will not be available and upon the quantity and temperature of the water needed.

Average Hot Water Requirements.—Many individuals have little conception of the amount of hot water required for either domestic or commercial purposes.

It should be clearly understood that when 30 gallons of water at 150° F. is mixed with an equal quantity at 50° F. the temperature of the 60 gallons will be 100° F. The temperature of bath water is usually about 98° F., whereas 120° F. is scalding temperature. It is therefore apparent that if a relatively

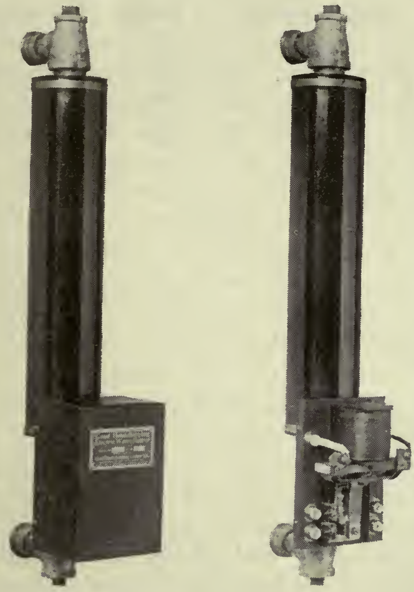


"Therm Elect" Immersion Heater and Thermostat.



Hughes Circulation Heater Applied to Tank.

small quantity of water is heated to a high temperature, it will afford a considerably larger amount when diluted with cold water for ordinary use. The hot water requirements of hotels, restaurants, barber shops,



Good Housekeeping Automatic Temperature Control Circulation Water Heater.

and other commercial users is generally underestimated, and it is advisable to give each proposed installation careful preliminary consideration.

Installation of Thermal Storage Water Heaters.

Correct Plumbing Essential.—The relative position of the tank and heater, the connections between the two, the size of tank and pipe used, the elimination of air pockets, and many other plumbing features are worthy of serious consideration when a thermal storage water heating system is installed.

The tank used with equipments operated under pressure should be mounted vertically to insure maximum difference in temperature between the top and

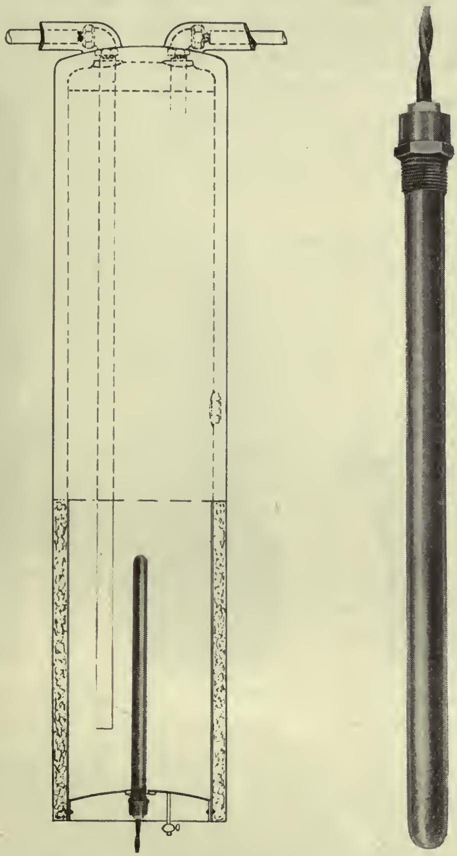
bottom, to obviate mixing the hot and cold water when the supply is drawn off rapidly, and to create better circulation of water through the heater. Standard tanks are usually fitted with two taps at the top. The tap used for connecting the tank to a water main should be provided with an inside pipe connection so that the cold water will be delivered to within a few inches of the bottom. It is necessary to have a very small hole drilled in this vertical pipe near the top of the tank to prevent the water being drawn out by syphonage whenever a hot water faucet is located below the level of the tank and a possibility exists of the pressure being withdrawn. Instances of where this precaution is necessary are often found in country residences when the domestic water supply is furnished from a pressure or storage tank. It is obvious that if the water is syphoned out of the water tank the heater will become dry and possibly burn out.

Installation of the Heater.—Immersion type heaters are usually, though not necessarily, inserted in the bottom of the tank. Circulation type heaters should be installed as close to the storage tank as possible. Better circulation will obtain if they are mounted vertically, and in such a position that the lower portion of the heating element will not be higher than the bottom of the tank. Rapid circulation is not always desirable, however, as the water passing through may not take up enough heat to produce the desired difference in temperature between the top and bottom of the tank.

Pipe Connections.—Circulation type heaters should be connected with pipe unions to permit of their quick and easy removal for inspection, cleaning, or repairing. Unless an electric heater is of extremely large capacity in proportion to the size of the storage tank, its upper end should be connected either to the hot water outlet or to a special tap near the top of the tank, rather than to the standard side outlet usually provided. If the hot water coming from the heater is delivered at or near the top, rather than at the side, it will be found that the circulation will be better and that a quantity

of hot water can be drawn from the tank much more quickly than otherwise.

By-Passing.—The pipe connections at the top of the tank should be carefully arranged. The hot water distribution pipe should lead straight out of the tank, and the connection from the heater should connect to

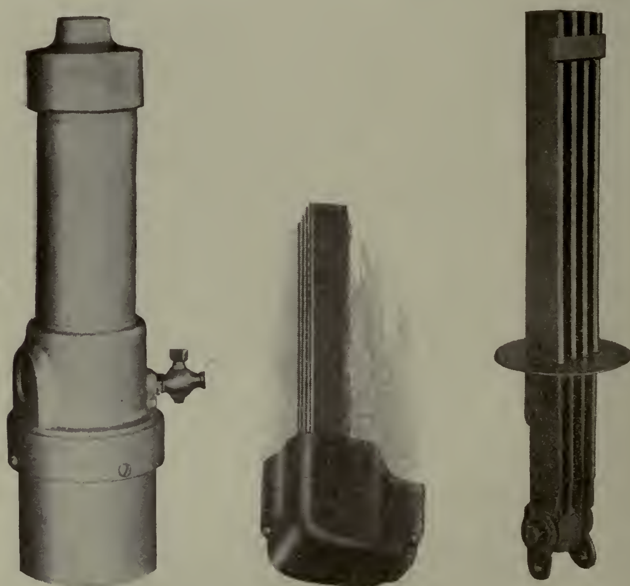


Epco Immersion Heater showing Application to Tank.

it from the side as close to the tank as possible. If this precaution is not taken the water drawn out through the distribution pipes may come partially from the top

of the tank and partially from the bottom on account of the rapid suction of cold water through the heater. The action produced is somewhat similar to that in an ordinary atomizer and is called by-passing. Some manufacturers recommend the use of special "non-by-pass tees" to entirely obviate this difficulty.

Air Pockets.—Unless the plumbing is properly done and the hot water distribution pipes are free from air pockets, unsatisfactory operation is likely to be



Cutler-Hammer Circulation and Immersion Type Heaters showing Form of Heating Elements.

charged to the electric heater. Air pockets are formed when the water is carried up and finally delivered at a lower point. The air gradually collects at the highest point and prevents the passage of water. The only relief from such a condition is the placing of an air cock at the highest point, or a rearrangement of the piping system.

Design of Distribution System.—The arrangement should be such that the storage tank will be situated

as near as possible to the central point of distribution. Connections between the tank and faucets should be made by the shortest routes, and the pipes should not be larger than is absolutely necessary for satisfactory service. The longer and larger the pipes that are used, the greater will be the loss through radiation from their surfaces.

So-called "return systems," wherein hot water is allowed to circulate continuously from the top of the tank, through the distribution pipes, and back to the bottom of the tank, will be found to require much more energy for their operation than ordinary systems, on account of the constant heat losses that take place from the surface of the pipes.

Storage Tank and Pipe Lagging.—As heretofore suggested the proper lagging of tanks and piping systems is often of as much importance as provision for adequate heater capacity. The kind of material employed should be carefully considered and the most approved methods of application adopted. Unless good lagging is used and properly applied, the operating efficiencies of the heating system may be greatly impaired. A few of the commonly known types of lagging materials are described and the methods of application outlined.

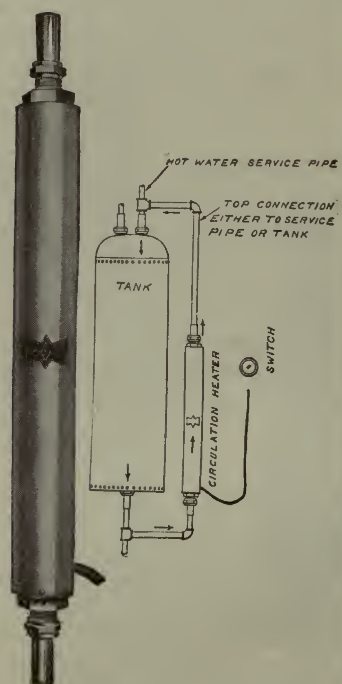
Keystone Tank Cover.—This form of lagging consists of a 3/8 in. layer of compressed hair felt having an asbestos lining, and a canvas cover. Experiments show that this form of lagging will prevent at least 50 per cent of the usual radiation losses from the sides of an exposed tank.

Keystone covers should be laced tightly. The upper edge of the cover should be allowed to project at least half an inch above the side edges of the tank. The top of the tank should then be covered with a half-inch layer of cement and pasted over with six-ounce drill.

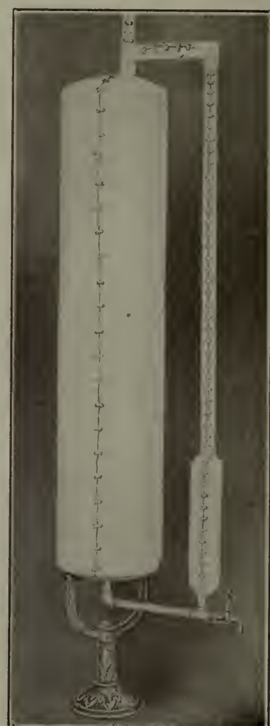
Economy Tank Covers.—The Johns-Manville Economy tank covers are made up of 1 in. hair felt lined with asbestos and covered with a canvas jacket. They are designed to fit the standard water tanks. The top

and sides are in one piece and may be laced tightly around the tank. A rope wrapped temporarily about the jacket will hold it in place and make the lacing much easier.

When the tank is exposed the canvas jacket should have a coat of sizing and be painted with two coats of cold water paint or lead and oil.



Simplex Heater and Standard Pipe Connections.



Economy Covering Applied to Tank and Pipes.

The manufacturers claim an efficiency for this form of lagging of from 85 per cent to 90 per cent. Although Economy covers cost about twice as much as Keystone covers the increased savings which they effect warrant their use.

Directions for Lacing Tank Covers.—Start lacing at the top of the cover. Tie the end of the lace to the right hand eyelet and thread it over to the opposite eyelet. Make two loops and then lace diagonally under the cover to the eyelet below the first and make two loops. Repeat the process until the last pair of eyelets is reached and then make three loops. Lace one of these loops back and tie it to the lace end by means of a bowknot beneath the cover.

Block Lagging.—Many forms of heat insulating blocks for lagging the larger sized tanks are available. One inch thickness is usually recommended for water tanks and the insulating efficiencies may be figured at from 80 per cent to 90 per cent depending upon the material used and the care with which it is applied. The blocks usually come in strips about 6 in. wide and 3 ft. long.

For lagging the sides of a small tank the blocks are usually cut in strips about 3 in. in width so that they will more nearly conform with the surface contour. These strips are then placed around and lengthwise of the tank and held in position temporarily with a small rope. The blocks are allowed to project about 1½ in. over each end of the tank to conform with the top and bottom lagging. Soft annealed wire (about No. 16 gauge) is then wound around the blocks and tightened up so as to hold them firmly in place. The blocks are then beaten down into shape with a wood paddle or mallet so that no air passages may be left between the covering and the tank.

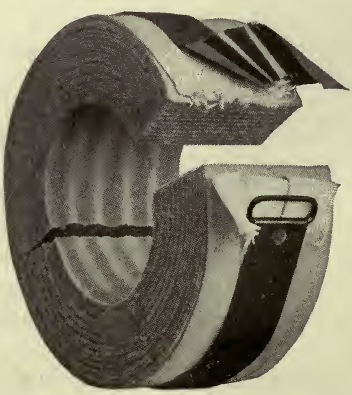
Cement is then mixed with water to about the consistency of ordinary mortar and applied to the outside about ½ in. in thickness by means of a trowel. All cracks and crevices should be filled, and the surface made smooth and even. A six-ounce drill jacket is then pasted on the outside. Flour and water may be used for paste. The salvage edges of the drill should be torn off, before it is dipped in the paste, to prevent puckering.

The ends of the tank are usually lagged with small blocks wired in position (when possible), pounded

down, coated with cement and a drill cover pasted on in a similar way to that suggested for the sides. When the tank is convex at the bottom or so mounted that the blocks cannot be placed in position, a coating of soft cement is put on the surface of the tank first. The blocks will then adhere to the outside while the next coating of cement is trowelled over them and the covering is put in place.

Pipe Lagging.—A large variety of coverings are available for lagging pipes and fittings. Sectional pipe covering which may be hinged over, pasted together by means of a lap in the canvas jacket, and held secure with brass bands, is most commonly used. It may be secured in thicknesses varying from ½ to 3 inches, but for water piping, 1 in. thickness is ample. It is usually made up in 3 ft. lengths. The savings in heat that may be effected by the careful lagging of pipes and fittings are enormous. Fifty feet of 1 in. pipe for instance, has approximately the same area as a thirty gallon tank, and filled with water at the same temperture, will radiate heat just as rapidly.

It is of the utmost importance that the pipe leading from the heater to the top of the tank should be lagged when water is heated by the circulation method. The water circulates constantly in this portion of the system as long as the heater is in service.

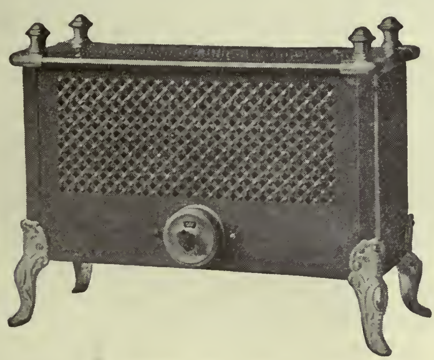


J. M. Asbestocel Sectional Pipe Covering.

CHAPTER VIII

ELECTRIC HEATING OF BUILDINGS.

Use and Advantages.—Were it possible to heat buildings with electricity at no greater cost than with combustion methods, it would be only a matter of time until they would all be heated electrically on account of the many superior advantages afforded. The present high cost of generating and distributing electric energy, however, precludes its universal application as a substitute for fuel heat. It is only in localities where fuel is very costly, or where electricity may be used for heating during off-peak seasons or off-peak hours, that extensive use may be made of it as an

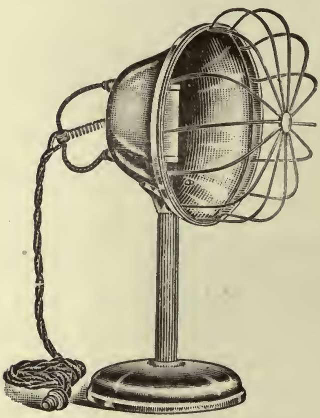


Westinghouse Convection Heater.

air heating medium. In some sections of the west, where water power is used extensively for irrigation pumping in the summer, it has been applied during the winter season to the heating of buildings with considerable success. The energy so used, which might otherwise be wasted, is turned into a useful by-product and sold at a low rate in competition with coal and other fuels, at the same time netting the central stations a small profit.

Some attention has also been given to the development of electric heating systems designed to make use of the great heat storage capacity of water, and so arranged as to heat large quantities of it during off-peak hours for use in warming buildings. Where conditions are favorable this method should find a wide application.

In a general way it may be stated that electric energy is too costly to compete with ordinary fuels, but where the cost of heating a building is a relatively unimportant item in comparison with the desire for



Majestic Radiant Heater.

General Electric Convection Heater.

convenience, it is certain to meet with favor. For heating small offices, bath rooms, sick rooms, cold corners, and for taking the chill out of the air during mild weather its use is ideal.

Electricity has the peculiar advantage of being instantly available, and regulated at will. It neither destroys oxygen nor vitiates the atmosphere. It is the cleanest and safest known method of heating. Among the advantages of electric heaters, are ease of installation, simplicity of operation, portability, flexibility of location, and small floor space required.

There are certain customers in nearly every locality that are willing to pay for the luxury afforded by electric heat, regardless of its cost, provided its ad-

vantages are made known to them. These individuals, in most instances, may be readily singled out and desirable business secured with little effort.

Comparative Cost of Fuel and Electric Heat.—It should be understood that electric air radiators always operate at 100 per cent efficiency, whereas coal and gas apparatus may often operate at efficiencies as low as 10 per cent. By referring to the comparison of costs of fuel and electric heat set forth in Chapter I, it will be noted that 600 B.t.u. gas at $1.00 per thousand cubic feet operating at 20 per cent efficiency is about equivalent to electricity at 3 cents per kilowatt hour.

Hughes Convection Heater.

Electric Heating Systems.—A large variety of systems of electric heating are in use, but few data are available to show their relative efficiencies and merits. On the assumption that the application of electricity to the heating of air is 100 per cent efficient, it is obvious that the essential feature to be considered with each system is the proper distribution of the heated

air. If the heat is intense near the heater or radiator and other parts of the room are cold the results will not be satisfactory. It is essential, therefore, that the system employed should not only heat the air but should set up convection currents that will serve to distribute it. The size, type, operating temperature, and design of the heaters have much to do with this particular feature.

The commonly known methods of electric heating are (1) by radiant heaters, (2) by convection heaters, (3) by oil and water radiators, (4) by indirect air heating systems, and (5) by steam and hot water circulation systems.

Radiant Heaters.—Radiant or luminous type heaters are made in a variety of styles and sizes. The heat-

Estate Convection Heater.

ing elements may consist of coils of exposed wire or filaments within glass globes, which are heated to a glowing temperature. The units are usually mounted in front of polished reflectors which focus the heat in any desired direction. Some radiant heaters are man-

Westinghouse Flush Type Radiant Heater.

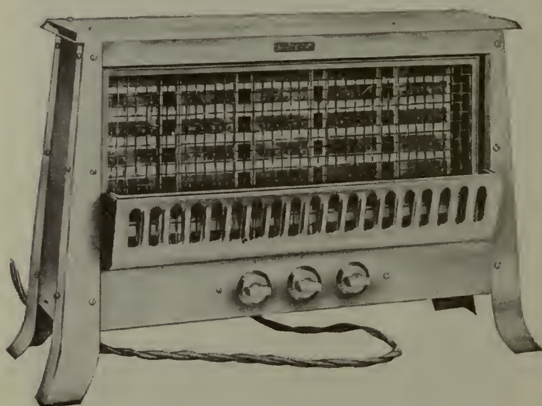
ufactured in small portable sizes, whereas others are made for use in open fireplaces or for flush wall mounting.

The heat from glower type radiators is like sunshine in that it only raises the temperature of a body which is opaque to heat waves. It passes through the air without heating it perceptibly, and only causes a rise of temperature in the air by heating objects that offer opposition to its passage, these objects in turn heating the air in contact with them by conduction.

Heat waves are unaffected by air currents and glower type radiators are therefore convenient for warming portions of the body or for warming a person in a large open space. The light, cosy glow which they

emit makes these heaters very attractive and cheerful in the home or office.

It is often thought that a glow type radiator, in front of which it is uncomfortable to hold one's hands, must be emitting more heat than a resistance type, over which they may be held for any length of time



Hot Point Radiant Heater.

without any sense of discomfort. This impression is wrong, because all the energy delivered to any electric heater, regardless of the type, is transformed into heat energy. The glower type heater concentrates the heat by means of polished reflectors, while the resistor type distributes the heat through the air. Uniform temperature throughout a room cannot readily be attained with a glower type heater.

Convection Heaters.—Heaters of this type are also manufactured in a variety of sizes and capacities. They usually consist of coils of resistance wires or ribbons mounted on ornamental frames, surrounded with a sheet metal or cast iron casing, with openings above and below to permit the free passage of air through the coils. The elements are generally designed for operation at temperatures below the red heat. The warmth generated by this type of heater is transferred to the air by direct contact with the hot resistance elements

and the surface of the heater. Convection currents are consequently set up which tend to equalize the room temperature. Much depends upon the design of this type of heater, if proper heat distribution is to be attained. The construction should be such as to develop ample circulation of air through the heated coils.

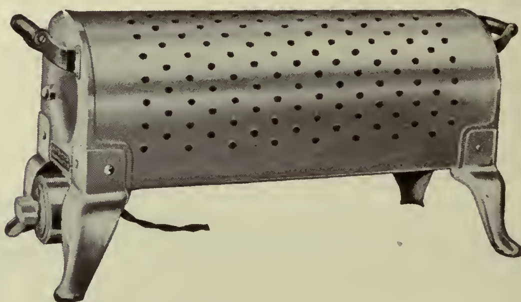
Convection heaters should never be mounted flush with the walls. They should be set a short distance away from the sides of a room. Where this is impossible, guards should be mounted on top of the heaters to deflect the heated air toward the center of the

Simplex Convection Heater.

room. The tops of the heaters should be unobstructed in order to permit free passage of air. Two or more small heaters will always be found to give a better distribution of heat than a single large one. Heaters placed under windows will warm the air admitted to a room and tend to obviate unpleasant draughts. Convection heaters in capacities larger than 750 watts are usually provided with three-heat switches to permit operation at lower temperatures during mild weather.

Oil and Water Radiators.—A large number of oil and water radiators have been placed upon the market. They are usually made in the form of ordinary hot water radiators with the heating elements inserted in

the sides and immersed in liquids. Their chief advantage is in the greater radiating surface which they offer to the air in comparison with ordinary convection air heaters. The heating elements being submerged in the liquid operate at low temperatures and are less subject



Hot Point Convection Heater.

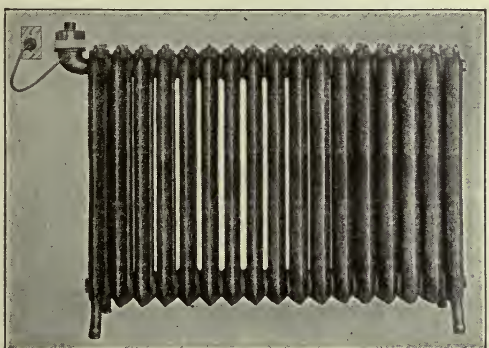
to oxidation. The water or oil which is used holds the heat for a considerable time after the current is shut off. The oil radiators may be operated at a higher temperature than the water radiators because oil vaporizes at higher temperatures. The disadvantages of this type of heater are the slowness with which it heats up, its greater weight and lack of portability, and its higher manufacturing cost, in comparison with convection heaters.

Indirect Air Heaters.—Radiators which are used to heat the air in a passage or flue which supplies air to a room are called indirect heaters. The radiators may consist of coils of wire or cast grid resistance mounted on a frame work so as to allow free passage of air and placed in a chamber or box at the foot of vertical flues leading to the rooms to be heated. Air is admitted to the chamber from the outside, and after passing through the heated resistance, it is taken directly into the flue. Ventilating fans may be interposed between the heating chamber and the outside in order to increase the volume of air.

Installations of this character in individual capacities of several hundred kilowatts have been in

successful service for a number of years. The chief advantages have been found to be a marked saving in floor space, ease of operation, cleanliness, and lack of attention required.

Steam and Hot Water Systems.—Electrically heated steam and hot water systems are similar in every respect to ordinary fuel burning equipment, except that electric steam boilers and water heaters are substituted. A number of installations have been made which have proved very satisfactory. The chief advantages are even heat distribution, ease of operation, freedom from dirt, soot, and ashes, and



Apfel Water Radiator.

less attention required. It is apparent, however, that unless buildings are already equipped with steam or hot water heating systems, the cost of installation will be considerable greater than for direct air heating systems.

Installation of Electric Heaters.—The use of numerous small heaters of three kilowatts capacity or less, each provided with three-heat switches, creates a better diversity of load for the central station than a few large single heat heaters.

Many concerns require that buildings wired for electric heating shall be provided with 220 volt service in order to prevent the use of lights and lamp socket devices on special heating circuits. Such pro-

vision has the further advantages of reducing the costs of wiring and service connections and producing better balanced load conditions.

In making installations of electric heaters of all types every facility should be provided for convenient operation, otherwise the habit of opening windows, rather than turning off the current when the room becomes too warm, will be encouraged.

Calculation of Heat Requirements.—The energy needed to heat a building or an individual room is the sum of the heat required to warm the air for proper

Radiator with Coin Circulation Water Heater Attached.

ventilation and that which is transmitted to the outside and lost. The former varies with the use for which the building is required, and the latter with the nature of its construction, exposure, etc. They both vary with the difference in temperature between the outside and inside of the buildings.

The two most commonly known ways of calculating the heat requirements of a building are (1) by

the use of the "B.t.u. method" and (2) by the application of an empirical formula. We shall call the B.t.u. method, the "watt method" because, for convenience, all calculations will be made with watts rather than with British thermal units. The watt method is naturally more accurate, whereas the empirical formula is easier handled. The empirical formula is based on the watt method but is more general in its application. It is convenient for making preliminary estimates.

Watt Method.—Calculation based on this method take into account the heat in watts (1) to heat the air required for ventilation as well as the air which leaks around windows, doors, and various crevices; (2) to supply the losses by transmission of heat to the outside through the walls, windows, floors, and ceilings. The sum of the watts required by a building for heating the air and for supplying the losses will determine the heater capacities.

Heat Absorbed by Air.—One cubic foot of air will absorb approximately 0.0054 watts per hour per degree Fahrenheit difference in temperature. In order to determine the amount of heat required for heating the atmosphere inside a building, it is necessary to multiply the number of cubic feet of air per hour admitted to the building by the difference between the outside temperature and that required within, and by the constant 0.0054.

i.e., quantity of air $\times$ temperature difference $\times$ 0.0054 = watts per hour.

The quantity of air admitted to a building depends upon (1) the ventilation required, and (2) the air leakage. Ventilation requirements may be fixed by law for some classes of buildings and for others the amount is usually fixed by the architects' judgment. The character and habits of the people living in a building also have much to do with its ventilation. The following table gives a fair average of the amount of air that is usually required for various kinds of buildings:

Air Required per Hour for Ventilation.

Hospitals	3000 cu. ft. per bed.
Assembly Halls	2000 cu. ft. per seat.
Factories and workshops	1800 cu. ft. per person.
Churches and Schools	2000 cu. ft. per person.
Offices	1800 cu. ft. per person.
Residences (a) Sleeping rooms	one complete change per hour.
(b) Living rooms	two complete changes per hour.
(c) Halls (with open stairways)	three complete changes per hour.

Heat Lost by Transmission.—The watts loss per square foot of surface per Fahrenheit degree difference in temperature, between the inside and outside of buildings and rooms, as set forth in the following table, seems to be pretty well established by the best authorities:

4-inch brick wall	0.193 watts
8-inch brick wall	0.135 watts
12-inch brick wall	0.093 watts
24-inch brick wall	0.058 watts
Reinforced concrete walls	1.2 x brick constants
Stone walls	1.3 x brick constants
Cement walls	1.5 x brick constants
Walls of frame buildings—plastered and sided	0.150 watts
Plastered partitions—lath and plaster both sides	0.100 watts
1-inch wood partition	0.120 watts
Wooden flooring (double board)	0.025 watts
Fireproof flooring	0.036 watts
Cement flooring	0.091 watts
Dirt flooring	0.068 watts
Wooden ceiling	0.031 watts
Plastered ceiling (no floor above)	0.094 watts
Plastered ceiling (single wood floor above)	0.076 watts
Wooden ceilings under slate or composition roof	0.088 watts
Wooden ceilings under iron roof	0.050 watts
Fireproof ceilings	0.048 watts
Wooden door	0.120 watts
Door 2/3 wood, 1/3 glass	0.170 watts
Single window glass	0.300 watts
Double window glass	0.170 watts
Single skylight	0.355 watts
Double skylight	0.185 watts

To obtain the watts lost by transmission, multiply the areas of the respective surfaces, by the temperature difference between the exterior and the interior of the building or room, and by the wattage constants in the above table.

i.e., area $\times$ temperature difference $\times$ constant =watts transmitted.

Air Leakage.—A careful consideration of air leakage is of as much importance in the design of heating installations as is that of ventilation. The losses of heat on account of air leakage cannot be calculated readily, and are usually estimated. Air leakage simply

increases ventilation, and has the same effect, as far as temperature conditions are concerned.

Store and office doors that are opened frequently increase the changes of air inside materially. Crevices around doors and windows permit the leakage of air in amounts varying with their size. Wind pressure has a large effect on the heating of a building, as it forces air inside which has to be heated. Its effect is greatest in poorly constructed buildings. During windy weather, the air in a room on the windward side of many buildings will be found to change as many as four times per hour unless the casings are fitted very tightly.

It has been found that buildings having open elevator shafts, skylights, open staircases, open fireplaces, etc., require more heat than those not having these features. More heat is always required on a mild windy day than on a cold still day. Humid atmosphere makes for greater comfort at lower temperatures, than is usually experienced with dry air.

The leakage losses, due to exposure of a building or room, depend to a greater extent upon the area of exposed walls than upon any other feature of the calculations, and are usually taken care of by adding a certain estimated percentage to the watts lost by transmission through the exposed wall and glass surface.

Factors of Safety.—It is impossible to determine accurately the exact heating requirements of any building, and the designer's judgment must, therefore, be relied upon to a great extent. The following coefficients, however, must always be considered in making up specifications for the heating of buildings or rooms:

Add 10 per cent to 50 per cent to transmission losses from sides exposed to prevailing winds.

Add 10 per cent to 25 per cent to transmission losses when building is heated only during the day.

Add 25 per cent to 50 per cent to transmission losses where building is heated intermittently with long intervals of non-heating.

Empirical Formula.—A vast number of empirical formulae have been developed for rapid calculation of the heating of buildings, but it is thought that the following formula will come closer to meeting the average requirements than most of those in use:

$$\left(\frac{NC}{180} + K\left(\frac{W}{8} + \frac{G}{3}\right)\right)(T_1 - T_2) = \text{Watts capacity.}$$

N = number of changes of air per hour.
C = cubical contents of building.
K = constant depending upon exposure and intermittent character of heating.
W = square feet of exposed wall surface.
G = square feet of exposed glass surface.
T_1 = inside temperature in Fahrenheit degrees.
T_2 = Outside temperature in Fahrenheit degrees.

Values of N:

$$N = \frac{\text{cubic feet of air required per hour for ventilation.}}{\text{Cubic contents of building.}}$$

$N = 1$ for residence sleeping rooms.
$N = 2$ for residence living rooms.
$N = 3$ for residence halls (with open stairways.)

Values of K:

$K = 1$ where walls are not exposed to prevailing winds.
$K = 1.1$ to 1.5 where walls are exposed to prevailing winds.
$K = 1.1$ to 1.25 where walls are not exposed to prevailing winds and building is heated only during the day.
$K = 1.2$ to 1.75 where walls are exposed to prevailing winds and building is heated only during the day.
$K = 1.25$ to 2 where building is heated intermittently with long intervals of non-heating.

This formula may be applied to any well constructed frame or brick building. Due allowance should be made for poorly constructed buildings. For use in any particular locality, the above formula may be modified to suit local conditions of temperature and types of building construction.

Application of Methods.—The following example is worked out by both the watt method and the empirical formula to show the application of the two methods of calculating heater capacities:

Assume 15 by 12 by 8 foot corner living room of a residence facing prevailing winds on two sides. The room has 8-inch outer brick walls, two single glass windows each having an area of 15 square feet, and an

outer wooden door having an area of 21 square feet. The temperature of the room is to be maintained at 70 degrees F., when the lowest outside temperature is zero degrees F. Other rooms in the house are to be heated to a similar temperature, and the losses through the partitions, floors and ceilings are therefore neglected.

Watt Method:		Watts.
Air	1440 cu. ft. $\times$ 2 $\times$ .0054 $\times$ 70 =	1088
Exposed walls....	165 sq. ft. $\times$ .135 $\times$ 70 = 1560 + 20% =	1872
Exposed windows.	30 sq. ft. $\times$ .300 $\times$ 70 = 630 + 20% =	756
Exposed door.....	21 sq. ft. $\times$ .120 $\times$ 70 = 175 + 20% =	210
Total		3926

Empirical formula method:

Substituting values in formula on p. 128:

$$\left(\frac{2 \times 1440}{180} + 1.2\left(\frac{165 + 21}{8} + \frac{30}{3}\right)\right)(70° - 0°$$

= Watts capacity.

$[16 + 1.2\ (23.25 + 10)\ ]\ 70 =$ watts capacity.

$(16 + 39.9)\ 70 = 3913$ watts capacity.

In order to properly heat the room a 2000 watt three-heat radiator should be installed under each window.

CHAPTER IX

INDUSTRIAL HEATING.

Scope of Application.—The field for the introduction of electric heat for industrial purposes covers a great variety of applications in which direct combustion methods and steam heat are now used. The present status of development is in a way comparable to that of the electric motor about a decade ago. The adoption of electric heat presents the same advantages over the older methods, that the electric drive does over the older methods of transmitting power. In nearly every industrial operation there is a demand for heat. The amount of power required is usually relatively small compared with the demand for heat. Many new industries have been created by the aid of electric heat through processes not otherwise possible. In other industries it has resulted in increased production, improved product, and decreased manufacturing cost.

Development of Field.—Only the general exploitation of proven appliances will result in a rational development of the industrial heating field. The adaptation of electric heat to many tools and appliances is apparently a simple proposition; but the economical and efficient accomplishment of a given operation calls for special knowledge comprising science and experience. The effect of correct design and proper application of heating devices upon the future success of the industrial heating business cannot be overestimated. The questions of heat insulation, thermal storage and thermal load factor have an important bearing upon the efficiency and economy of operation that must also be considered. The many cases where heat-

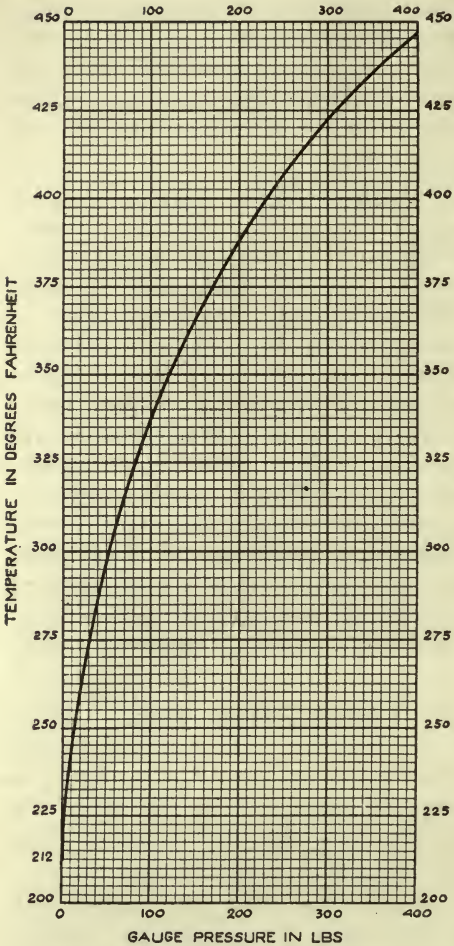
ing elements have been purchased and applied to apparatus of various kinds, and results obtained by the crudest methods, are not entirely desirable from the standpoint of rational development, but they furnish ample evidence of the tremendous field existing for the application of electric heat.

Advantages of Electric Heat.—Safety, convenience, flexibility and cleanliness are apparent in electric heating as well as in other electrical applications. Sanitary conditions are improved and labor is made more available and contented. Machines may be placed in the most advantageous positions without regard to the source of heat. Constant losses due to the transmission of heat are eliminated. Wide ranges of temperature for every kind of industrial work are obtained. Uniform, yet easily controlled temperatures which are not readily affected by air drafts are made possible. Any amount of heat may be generated efficiently, at any desired temperature, and under any desired atmospheric conditions. Ease of application, saving of labor and skill, improvement of product and reduction in floor space are other advantages of electric heat.

Comparison with Fuel and Steam Heat.—Gas or other fuels permit application of high temperatures but the heat produced is irregular and the flame is accompanied by soot and fumes which soil the work, and the hot vitiated air affects the health and comfort of the operators.

Steam gives a uniform heat, but the temperature is limited by the safe steam pressure that may be used. The accompanying curve and table shows the gauge pressure required to produce various temperatures in heating devices.

In many industries where steam is required in large quantities for low temperature work, it is found advantageous to use electricity for the high temperature operations. The many objections to the production of high temperature steam in manufacturing establishments are quite obvious.



Temperature Fahr.	Pounds Pressure
376°	172
377	174
378	176
379	178
380	180
381	183
382	185
383	188
384	190
385	193
386	195
387	198
388	200
389	203
390	205
391	208
392	210
393	213
394	216
395	218
396	221
397	224
398	226
399	229
400	232
401	235
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407	253
408	256
409	259
410	262
411	265
412	268
413	271
414	275
415	278
416	281
417	285
418	288
419	291
420	294
421	297
422	300
423	303
424	307
425	310
426	313
427	316
428	319
429	322
430	326
431	330
432	334
433	338
434	342
435	346
436	350

Curve and Table showing Gauge Pressure of Saturated Steam Corresponding to Increase in Temperature.

Heating Elements.—The more general application of electric heat has been delayed materially by the tendency to call for specially designed apparatus to meet every industrial need, in place of modifying the application to meet the conditions of standardized heat units.

Heating elements have been developed by different manufacturers of heating devices of such dimensions and thermal characteristics as to be readily applicable to many of the ordinary arts and trades. Rectangular, square, and round flat units, tubular cartridge units, and air drying or heating units of many shapes, sizes, and capacities are available for various applications. New alloys, improved electrical insulators of high thermal conductivity, and the more intelligent use of heat insulating materials, have done much to enlarge the possibilities of the electric heating field.

Heating Specifications. In determining the capacities of various industrial heating apparatus it is necessary to secure comprehensive data on the specific apparatus to which electric heat is to be applied, as well as on the actual working conditions which have to be met. The following will illustrate some of the points that have to be considered in industrial problems:

Heating of Water or Other Liquids:

(1) Nature of liquid.
(2) Size and shape of vessel.
(3) Temperature to be maintained.
(4) Time allowed for heating up.
(5) Amount of liquid to be heated.
(6) Material of containing vessel.
(7) Exterior surface of containing vessel (light or dark, rough or polished.)
(8) Cover of vessel.
(9) Kind and thickness of heat insulation.

Heating of Ovens:

(1) Size and shape of oven.
(2) Cycle of heating operation.
(3) Temperature to be maintained.
(4) Weight of material to be baked.
(5) How material is handled.
(6) Duration of process.
(7) Number of bakes required.
(8) Weight of trucks carrying material into oven.
(9) Character of oven insulation.
(10) Diameter and length of ventilating flue.

Electric Furnaces:

(1) Maximum temperature required.
(2) Kind of work to be done.
(3) Character of furnace to be adopted.
(4) Size and shape of chamber required.
(5) Quantity of work to be undertaken.

Branding Irons:

(1) Size and nature of the brand.
(2) Character of material.
(3) Wet or dry material.
(4) Speed required.
(5) Sample of material.

Irons, Glue Pots, etc.:

(1) Weight and size of devices now in use.
(2) Class of work to be done.
(3) Speed required.

Steam Generators:

(1) Feed water temperature.
(2) Pressure desired.
(3) Amount of steam in pounds per hour.
(4) Time allowed for bringing up to pressure.
(5) Dimensions of boiler.
(6) Character and construction of boiler.
(7) Boiler insulation.

Inasmuch as electric energy is ordinarily sold on the basis of maximum demand, as well as on that of energy consumption, it is necessary to design electric heating apparatus for low demand and long hour use, rather than high demand and short hour use. Arrangement for off-peak power consumption is also desirable when conditions will permit.

Apparatus designed with minimum wall surface in relation to content will obviously be more efficient than if made in other forms.

Applications of Electric Heat.—Perhaps the most important application of electric heat is found in the electrochemical and electrometallurgical industries where the electric furnace has revolutionized some manufacturing enterprises and actually created others.

In the metal trades industry electric welding apparatus, melting tanks, soldering devices, oil tempering

baths, annealing furnaces, and various types of self heated tools have many proven advantages.

Numerous heating operations in automobile, printing and publishing, paper, laundry, confectionery, and clothing industries, may be performed with a greater degree of satisfaction with electricity than with fuel methods.

The list of heating applications which follows will convey a general impression of the vast extent to which electric heat may be applied in the industrial field:

Heating Applications.

Automobile Factories and Garages:

- Vulcanizers.
- Varnish drying ovens.
- Welding apparatus.
- Hood heaters.
- Foot warmers.
- Rectifier tube boilers.
- Solution tanks.
- Disc stoves.
- Enameling furnaces.
- Soldering irons.
- Branding irons.
- Steering wheel warmers.
- Varnish tank heaters.
- Hardening furnaces.
- Oil tempering baths.

Barber Shops:

- Water heaters.
- Curling irons.
- Sterilizers.
- Cigar lighters.
- Hair dryers.
- Disc stoves.

Beauty Parlors:

- Hair dryers.
- Curling irons.
- Disc stoves.
- Cauterizers.
- Water heaters.
- Die tank heaters.

Boiler Shops:

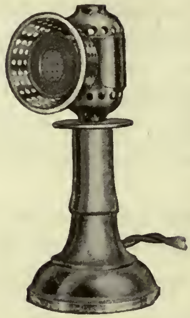
- Welding machines.
- Soldering irons.
- Hardening and annealing furnaces.

Bookbinding Shops:

- Matrix dryers.
- Embossing and stamping presses.
- Drying closets.
- Back shapers.
- Palette heaters.
- Branding irons.
- Glue pots.
- Case making and covering machines.
- Back rounders.
- Gilding wheel heater.

Breweries:

- Vat dryers.
- Glue and resin heaters.
- Branding irons.



G. E. Cigar Lighter.

Brush Manufacturers:
- Glue pots.
- Tank heaters.
- Branding irons.
- Flat irons.

Button Manufacturers:
- Hot plates.
- Japanning ovens.
- Button die heaters.
- Celluloid softeners.

Canning Factories:
- Can capping machines.
- Soldering pots.
- Soldering irons.
- Branding irons.

Cigar Stores:
- Cigar lighters.
- Branding irons.

Cleaning and Dyeing Works:
- Tailor irons.
- Hot plates.
- Laundry irons.
- Puff irons.

Cloak and Suit Manufacturers:
- Tailor irons.
- Velvet marking irons.
- Laundry irons.
- Puff irons.

Coffee and Tea Merchants:
- Percolators.
- Water heaters.
- Coffee roasters.
- Tea pots.
- Hot plates.

Colleges and Schools:
- Laboratory devices (listed elsewhere.)
- Hot plates (domestic science.)
- Ovens (domestic science.)
- Water heaters.

Confectioners:
- Hot plates.
- Chocolate warmers.
- Dipping tanks.
- Corn poppers.
- Batch warmers.
- Chocolate trays.
- Water heaters.
- Ovens.

Contractors and Builders:

Branding irons.
Soldering pots.
Soldering irons.
Glue pots.

Corset Factory:

Corset irons.
Disc stoves.
Form heaters.
Flat irons.

G. E. Glue Pots in Box Factory.

Creameries and Dairies:

Water heaters.
Hot plates.
Sterilizers.

Dentists:

Cauterizers.
Hot plates.
Vulcanizers.
Sterilizers.
Dental furnaces.

Department Stores:

Cigar lighters.
Hot plates.
Pyrograph needles.
Flat irons.

Doctors:

Sterilizers.
Hot bath cabinets.
Water heaters.
Cauterizers.
Heating pads and blankets.
Incubators.

G. E. Irons in Cleaning and Dyeing Establishment.

Dress Goods Factory:

Pleating machines.
Flat irons.
Ironing machines.
Velvet marking irons.

Drug Stores:

Cauterizers.
Sterilizers.
Sealing wax heaters.
Water heaters.
Cigar lighters.
Paper seal moisteners.

Electrotypers:

Heating furnaces.
Solder pots.
Soldering irons.
Water heaters.

Factories (General):

Welding machinery.
Branding irons.
Glue pots and cookers.
Pitch kettles.
Soldering irons.
Water heaters.
Solder pots.
Pouring pots.

Farms:

Incubators and brooders.
Soldering irons.
Hot plates.
Branding irons.
Sterilizers.
Food warmers.

Foundries:

- Steel furnaces.
- Welding machinery.
- Soldering irons.
- Metal melting tanks.
- Core ovens.
- Solder pots.

Furniture Factories:

- Wax knife heater.
- Glue pots.
- Wax burning-in iron.
- Drying ovens.

Hair Dressers:

- Hair dryers.
- Water heaters.
- Curling irons.
- Disc stoves.

Harness Shops:

- Branding irons.
- Water heaters.
- Wax heaters.
- Creasing irons.

Hat Manufacturers and Stores:

- Flanging bags.
- Velouring stoves.
- Machine irons.
- Hand flats.
- Hand shells.
- French irons.

Hospitals and Sanitariums:

- Cauterizers.
- Sterilizers.
- Water heaters.
- Mangles.
- Hot cabinets.
- Heating pads.
- Flat irons.
- Incubators.

Hotels:

- Sealing wax heaters.
- Hot bath cabinets.
- Tailors' irons.
- Hot plates.
- Cigar lighters.
- Laundry irons.
- Curling irons.
- Heating pads.
- Water heaters.
- Towel dryers

Jewelry Stores:

- Small drying ovens.
- Hot plates.
- Sealing wax heaters.
- Soldering irons.

Knitting Mills:

- Hosiery forms.
- Yarn conditioning ovens.
- Flat irons.

Laboratories:

- Annealing and enameling furnaces.
- Sterilizers.
- Disc stoves.
- Tube, crucible, vacuum, and muffle furnaces.
- Flask heaters.
- Shelf heaters.
- Water heaters.
- Soldering irons.
- Test tube heaters.
- Bacteriological incubators.

Laundries:

- Sleeve irons.
- Collar and cuff moulding machinery.
- Ironing machines and rolls.
- Starch cookers.
- Puff irons.
- Laundry irons.
- Marking machines.
- Steam boilers.
- Clothes dryers.

Installation of Simplex Laundry Irons Equipped with Suspension Cords.

Leather Factories:

- Leather creasing tools.
- Glue and wax heaters.
- Embossing machines.
- Crimping machines.
- Solution tanks.
- Branding irons.
- Flat irons.
- Wax knife heaters.

Libraries:

- Sealing wax pots.
- Paper seal moisteners.
- Envelope gum dryers.
- Glue pots.

Machine Shops:

- Welding machinery.
- Soldering irons.
- Metal melting tanks.
- Branding irons.
- Oil tempering tanks.
- Solder pots.
- Solution tanks.
- Oven furnaces.

Offices:

- Sealing-wax heaters.
- Paper seal moisteners.
- Envelope gum dryers.
- Water stills.

Paper Box Factories:

- Box mould heaters.
- Sealing wax heaters.
- Drying ovens.
- Glue pots.
- Branding irons.
- Disc stoves.

Photographers:

- Burnishers.
- Glue pots.
- Fan dryers.
- Flat irons.
- Film and print dryers.
- Branding irons.
- Wax heaters.
- Disc stoves.

Piano Stores and Factories:

- Drying ovens.
- Glue pots and cookers.
- Solution tanks.
- Branding irons.
- Soldering irons.
- Annealing furnaces.

Plumbers and Tinsmiths:

- Roofing pitch kettles.
- Solder pots.
- Pipe thawing apparatus.
- Soldering irons.

Peanut and Popcorn Stands:

- Peanut roasters.
- Popcorn poppers.
- Peanut warmers.
- Butter warmers.

Printers and Publishers

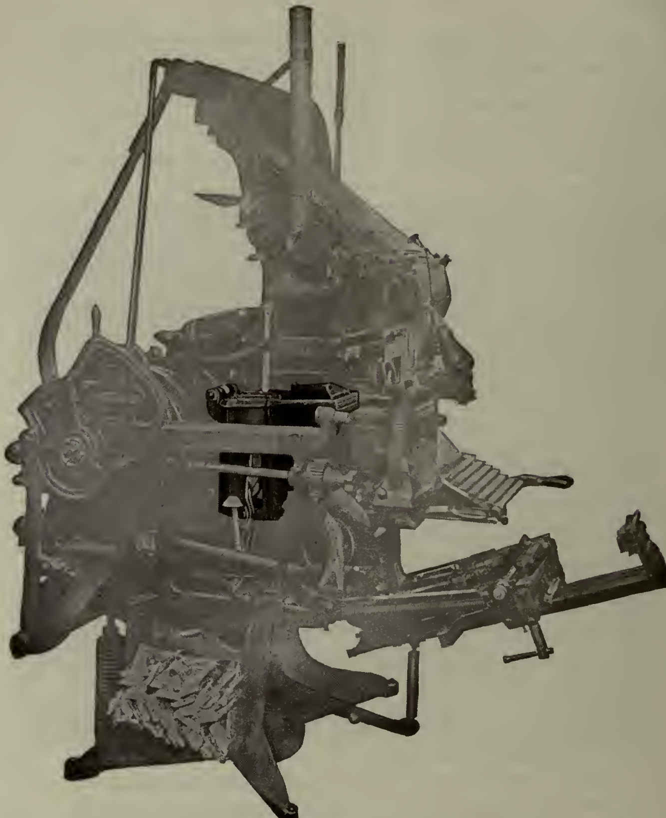
- Linotype and monotype pots
- Metal melting tanks.
- Matrix dryers.
- Back rounders.
- Embossers.
- Printing press heaters.
- Branding irons.
- Wax-heating kettles.
- Glue pots and cookers.
- Back shapers.
- Palette heaters.
- Printing ink heaters.
- Drying rooms.
- Stamping and embossing presses.
- Wax-stripping tables.

Restaurants:

- Coffee urns.
- Toasters.
- Food warmers.
- Bake ovens.
- Griddles.
- Cigar lighters.
- Waffle irons.
- Plate warmers.
- Steam tables.
- Broilers.
- Egg boilers.

Roofers:

- Branding irons.
- Solder pots.
- Soldering irons.
- Pitch kettles.



Linotype Machine Equipped with Coin Melting Pot.

Saloons:

Hot plates.
Cigar lighters.
Plate warmers.
Water heaters.
Percolators.

Ship Building Yards:

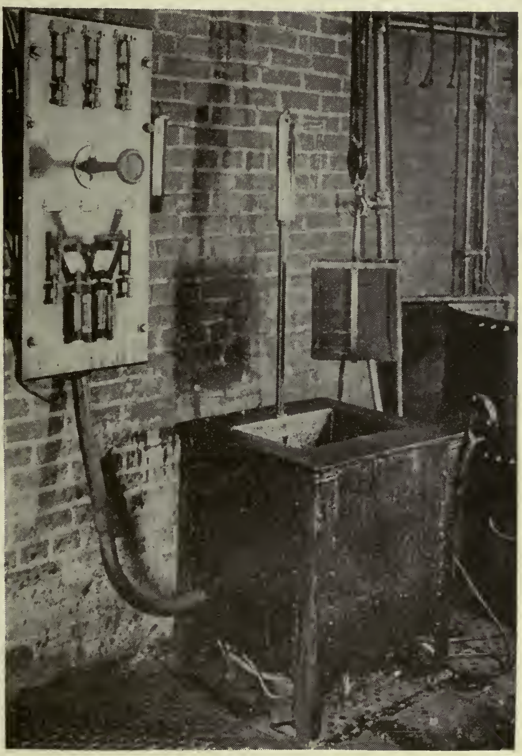
Welding machines.
Soldering irons.
Glue pots and cookers.
Branding irons.

Shirt Factories:

Laundry irons.
Ironing machines.
Disc stoves.
Flat irons.
Tailors' irons.
Cuff and collar moulding machines.

Shoe Factories and Stores:

- Thread waxing machines.
- Lining cementer.
- Stitchers.
- Embossing machines.
- Welters.
- Branding irons.
- Flat irons.
- Turn and welt machines.
- Knurling machines.
- Patent leather repairers.
- Indenters and burnishers.
- Embossers.
- Glue pots and cookers.
- Shoe relasters.
- Wax knife heaters.



G. E. No. 3 Oil Tempering Bath in Atlas-Ball Plant, Philadelphia.

Steel Mills:

- Welding machinery.
- Oil tempering tanks.
- Steel furnaces.

Street Railway Shops:

- Car heaters.
- Soldering irons.
- Water heaters.
- Welding machinery.
- Solder pots.
- Branding irons.

Tailor Shops:

- Tailors' irons.
- Clothes dryers.
- Puff irons.

Theatres:

- Water heaters.
- Curling irons.
- Grease-paint heaters.

Turkish Baths:

- Hair dryers.
- Hot bath cabinets.
- Water heaters.
- Curling irons.

Wagon Shops and Factories:

- Vulcanizers.
- Branding irons.
- Soldering irons.
- Welding machines.
- Glue pots and cookers.
- Disc stoves.

Wood Workers and Carpenters:

- Branding irons.
- Wax melters.
- Glue pots.
- Soldering irons.

CHAPTER X

ELECTRIC FURNACES.

Economic Advantages.—The use of electric energy for producing furnace heat has revolutionized many modern industries. The field which it has created in the development of electrochemical and metallurgical processes has great possibilities. Not only does the electric furnace afford opportunity for improving and widening these industries, but its use requires large quantities of electric power, the development of which produces a market for energy that might otherwise lie dormant or go to waste. Furthermore it improves the load factor and diversity of large central station loads, and otherwise tends to foster greater economic wealth.

Only high temperature furnaces for melting and refining various substances will be considered in this chapter. The general design, manner of operation, and field of application of electric furnaces will be outlined so as to convey an understanding of the subject.

The Electric Furnace Field.—The application of the electric furnace has made it possible to manufacture a number of substances that would otherwise not be available for commercial purposes if combustion methods were the sole means of production. None other than electric furnace methods have ever been successfully employed in the manufacture of such well known substances as carborundum, aluminum, and calcium carbide. Immense industries have been built up, and great quantities of power employed for their production. There are many other processes that may be performed only with the electric furnace, but the extensive applications of which are limited by the cost of production. There is little doubt but that more of the supply of nitrogen required for soil fertilization

will be drawn from the air by electric furnace apparatus, as the present rapidly depleting natural nitrate deposits become exhausted. Several plants located where electric energy is cheaply produced, now manufacture great quantities of nitric acid and nitrates and consume enormous amounts of power.

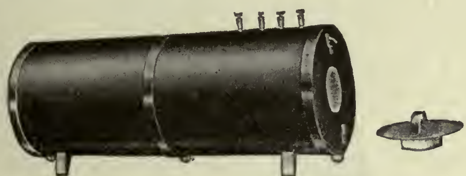
Pouring From Snyder Steel Furnace.

The electric furnace may create temperatures greatly in excess of those otherwise available. With present apparatus operating temperatures as high as 6500° F. may be attained. The exclusion of objectionable furnace gases and air, makes it possible to perform many new operations. The smelting of various metallic ores that formerly could not be handled satisfactorily or economically has been made possible.

Probably the greatest field for utilizing the electric furnace, at the present time, is in its application to such processes as are now largely performed with fuel burning furnaces. It is in this field, however,

that the electric method has to compete on the basis of both cost and quality of product.

Character of Furnace Power Loads.—Some concerns using electric furnaces do not attempt twenty-four hour operation on account of the usual inefficiency of night work. This is especially true of those engaged in steel manufacturing. Some furnaces have to be shut down while the products are removed and new charges introduced. The resulting load factor is relatively high, however, as compared with average central station motor service.



G. E. Laboratory Tube Furnace. (Max. temp. 1832° F., 2½ in. diameter, various lengths.)

Some smaller furnace installations may be shut down from three to four hours per day without serious disadvantage and this condition often makes it possible to utilize off-peak power. Where steel melting furnaces are used, it has been found advisable in many instances to mould during the day and melt at night. This practice has developed an all-night furnace load for the power company.

The variations in current in an electric furnace are usually due to changes in condition of the charge. Some furnaces are operated in series with a ballast. For direct current service the ballast has to be a resistance, whereas for alternating current service a resistance or a reactance may be used. The power factor of induction furnaces is generally low. It may be raised by lowering the frequency, or by using a synchronous motor as a condenser.

Character of Service Required.—Alternating current is used in furnace work more often than direct current. For induction furnace operation alternating current is employed, whereas direct current is required

in electrolytic furnaces. In most arc and resistance furnaces either alternating or direct current may be employed.

The voltage required for furnace work is generally low (50 to 200) although in nitrogen furnaces pressures as high as 5,000 to 10,000 volts are often utilized. The size of furnace loads usually makes it necessary to reduce the voltage at the point of delivery, and consequently almost any available primary

G. E. Crucible Furnace. (Max. temp., 1112° F., crucible 1 in. by 2 in. high.)

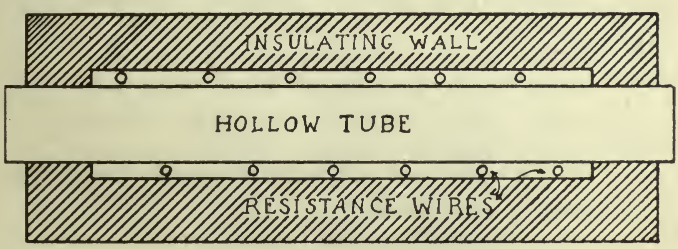
voltage may be used. The higher the voltage applied the less is the current required, the smaller the electrode cross section, and the less the heat conducted out of the furnace through the electrode. Voltages are limited, however, from considerations of the safety of operators.

Arc and resistance furnaces are usually built for 60 cycle operation in sizes under 1000 kilowatts. Larger furnaces are generally constructed for lower frequencies. Induction type furnaces usually require special low frequencies in sizes larger than 500 kilowatts capacity.

Most furnaces are operated with single-phase service. The larger resistance furnaces for manufacturing chemical products, graphite, and carbide use single-phase service. Nitrogen fixation furnaces are generally connected so as to use three-phase current. Two and three-phase energy is frequently utilized in steel making although it is contended by some manufacturers that single-phase service is more efficient

and satisfactory from the standpoint of furnace operation. A single electrode furnace is somewhat cheaper and more readily manipulated; the heat losses are less; and the electrode and refractory roof costs are smaller. On the other hand, most power producers prefer to deliver two or three-phase energy for obvious reasons. Central station companies having 4-wire, three-phase distribution systems are sometimes able to supply single-phase service by suitable arrangement of tranformer connections.

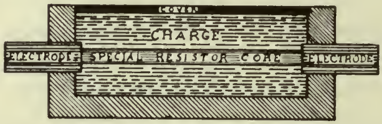
Classification of Electric Furnaces.—Electric furnaces may be divided into two general classes, the resistance type, and the arc type. It is often difficult to distinguish the class to which different furnaces belong, because both the heat of the arc, and the heat resulting from the resistance to the flow of current, are frequently utilized in heating the charge.



Tube Furnace.

Resistance type furnaces may derive heat from the passage of current through resistance wires, through other resistance materials surrounding the charge, or by the passage of current through the charge itself. Examples of furnaces employing resistance wires as a means for heating the charge are found in the ordinary small crucible, tube, and muffle type furnaces often used in laboratories for operation at temperatures under 1800° F. Typical examples of the second type of resistance furnaces are those of the Acheson carborundum furnace and some of the well known high temperature electric crucible furnaces. The induction type furnace, wherein a current is induced in the charge by electromagnetic induction,

is one of the best examples of the third type of resistance furnace. A sharp distinction between these three classes is often impossible because some types involve more than one principle in their design.



Furnace With Resistance in the Charge.

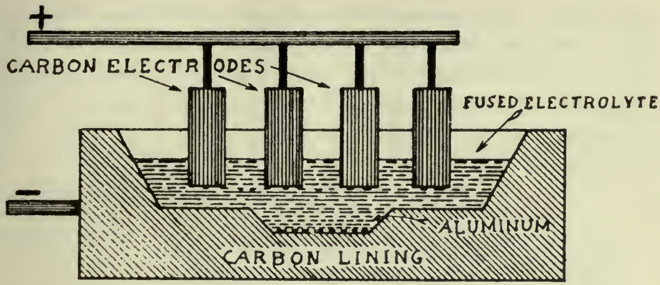
Arc furnaces may be divided into three classes, the principles of which may or may not be combined in one type of apparatus. The first class, known as the direct arc furnace, produces heat by causing an arc between the electrode and the charge. The second class known as the series arc furnace passes current from one electrode to the charge and from the charge back to another electrode. The third class, known as the indirect arc furnace, produces heat between electrodes supported above the charge.

A more complete classification of electric furnaces is given by Stansfield in his excellent text on "The Electric Furnace" as follows:

Classification of Electric Furnaces.

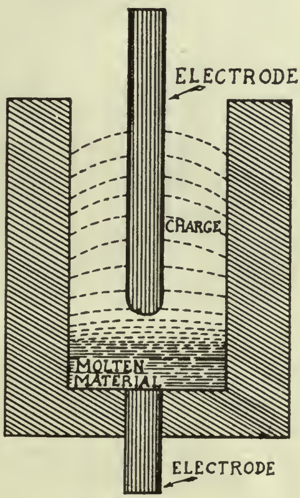
(1) Resistance Furnaces.
- (a) Using special resistance.
  - (1) Resistance wires in furnace walls (tube furnace.)
  - (2) Resistance material in the charge (carborundum furnace.)
- (b) No special resistance.
  - (1) Electrolytic (aluminum furnace.)
  - (2) Using charge as resistance.
    - (a) Solid material (graphite furnace.)
    - (b) Melting material (Heroult smelting furnace.)
    - (c) Liquid material (induction furnace.)

(2) Arc furnaces.
- (a) Direct arc.
  - (1) Single arc (Girod furnace.)
  - (2) Series arc (Heroult furnace.)
- (b) Indirect orc (Stassano furnace.)



Aluminum Furnace.

Advantages and Limitations of Electric Furnaces. The increased range of temperatures, the easy control of the heat generated, the exclusion of harmful ingredients, and the careful adjustment of atmosphere conditions, make the electric furnace ideal for many electrochemical operations.



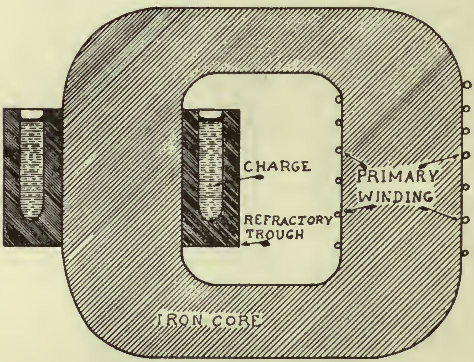
Shaft Furnace.

Comparisons are sometimes made between the cost of fuel and the cost of electricity and these figures used as a basis for deciding what method of heating should be employed. In so doing some important

considerations are frequently overlooked. In the first place, the efficiency of a furnace is the ratio between the heat beneficially utilized, and the heat energy supplied. The average efficiencies of a number of different types of furnaces are given on good authority as follows:

Furnaces	Average Efficiency Per cent.
Coke fired crucible steel furnaces	2.5
Metal melting reverberatory furnaces	12.0
Open-hearth steel furnaces	25.0
Shaft furnaces	40.0
Large electric furnaces	75.0

It is apparent that although the number of heat units made available in the fuel furnace may exceed those in the electric furnace for the same expenditure of money, the higher efficiency of the latter may prove its superiority.



Induction Furnace.

Heat Energy Required.—The heat consumed in the electric furnace is utilized and dissipated as follows:

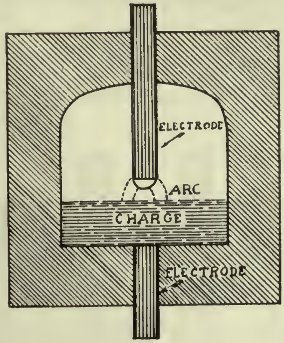
(1) To raise starting materials to temperature of reaction.

(2) To change the state of the substance as required.

(3) To provide energy for the reaction.

(4) To supply the conduction and radiation losses.

The first item may be calculated by multiplying the weight of the charge, the temperature difference, and the mean specific heat. The second may be obtained by multiplying the weight of the charge by the latent heat of fusion, vaporization, or sublimation,



Direct Heating Arc Furnace.

according as it is required to change from solid to liquid, liquid to vapor, or solid to vapor respectively. The third may or may not absorb useful heat energy and in some cases actually produces heat within the charge which reduces the amount of outside energy required.

Conduction losses take place mainly through the furnace walls and through the electrodes. The heat losses through the walls depend upon the thermal conductivity and area of the walls and the difference in temperature inside and outside the furnace. Heat losses through the electrodes depend upon their thermal as well as upon their electrical conductivity, for the reason that heat is conducted from the hot to the cold ends, and generated in the electrodes by the passage of current. The radiation losses depend upon the outside area of the furnace, the character of its surface, and the difference in temperature between its surface and that of the surrounding atmosphere.

Furnace Walls.—In the choice of material for furnace walls four properties of the substance are generally considered:

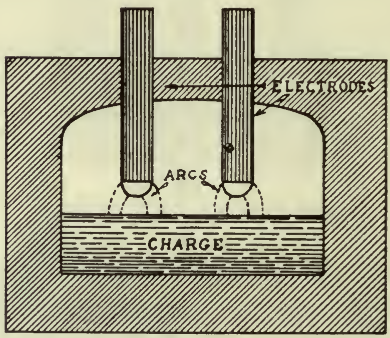
(1) Its fitness for the chemical nature of the reaction;

(2) Maximum temperature it is required to withstand;

(3) Its thermal conductivity;

(4) Its ability to withstand expansion and contraction.

For a basic charge a basic refractory is required and for an acid charge an acid lining is essential.



Direct Heating Series Arc Furnace.

Metallurgical Furnace Refractories.

Basic Lining.	Acid Lining.	Neutral Lining.
Bauxite	Silica	Carbon
Magnesia		Fire clays
Dolomite		Chromite
Lime		

For higher temperature furnace work certain compounds of carbon and silicon as well as pure carbon are especially adaptable. Pure magnesia is recommended for some purposes.

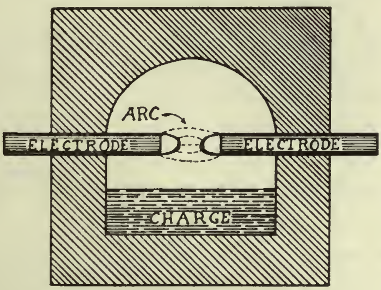
Furnace walls are usually constructed of two layers—the inner one capable of withstanding the maximum temperature and the chemical effects of the charge, and the outer one of high heat insulating quality.

Furnace Electrodes.—All electric furnaces, with the exception of induction apparatus, require the use of electrodes for introducing electric energy into them.

The most desirable qualifications of an electrode may be enumerated as follows:

(1) Good electrical conductor.
(2) Poor heat conductor.
(3) High melting or sublimation point.
(4) Lack of contaminating effect upon charge.
(5) Mechanical strength.
(6) Cheapness.

The relative importance of these qualifications depends largely upon the kind of furnace to which the electrodes are applied. On account of the losses



Independent Arc Furnace.

that take place through the electrodes it is essential that the dimensions and material be carefully considered. The consumption of electrode material in the furnace is another feature that has much to do with the furnace operating costs.

Electrodes are usually made of carbon. Graphite electrodes have the advantages of better resistance to oxidation, higher electrical conductivity, and greater purity, but they are more expensive.

CHAPTER XI

ELECTRIC FURNACE APPLICATIONS.

Fundamental Considerations of Commercial Enterprises.—The ultimate success of any industry based on the application of the electric furnace may depend upon any one of a number of local conditions:

(1) Availability, character, and cost of raw materials.

(2) Cost of transporting raw materials to furnace.

(3) Availability and cost of electric power.

(4) Availability, character, and cost of labor.

(5) Cost of transporting finished product to market.

(6) Extent, stability, and competitive conditions of market.

A casual observer is likely to assume that any enterprise requiring the application of the electric furnace depends solely upon cheap power for its success. That random conclusions of this sort are often misleading may be observed by applying the above six considerations to almost any commercial electric furnace project. It is true that electric equipments producing large quantities of cheaper grade products in competition with fuel apparatus often require very low power rates to insure success. On the other hand many refining processes are carried on to advantage where power costs are not extremely low.

The availability of raw materials, the proximity and cheapness of water transportation, and the labor and market conditions, considered aside from power cost, have each had a potent influence in determining the feasibility of locating electric furnace enterprises at Niagara Falls, and in France, Norway, Sweden, and Switzerland.

Production of Ferro-Alloys.—Iron alloyed with chronium, tungsten, manganese, silicon, etc., is known

as a ferro-alloy. It is somewhat similar to cast iron, but differs in that some of the metals or other materials have replaced part of the iron. The chief use of ferro-alloys is in the production of steel. The constituents are usually less costly to obtain in ferro-alloys than in the pure state. The small quantity of iron with which they are alloyed simply mixes with the charge in the furnace during the process.

Most of the ferro-alloys are produced by reducing the metallic oxide with iron or iron ore and carbon. Ferro-silicon is made by smelting a mixture of silicon, in the form of quartz or quartzite, with carbon, and iron or iron ore. The latter is of great value in the production of steel where it acts both as a deoxidizer and as a preventive of objectionable blowholes in steel castings.

The electric furnace has proven itself far superior to fuel furnaces in the production of ferro-alloys because of the higher and more easily controlled temperatures it affords, and on account of the absence of objectionable ingredients, and the higher percentage of desirable constituents in the product. The manufacture of many ferro-alloys formerly considered commercially impractical have been undertaken since the application of the electric furnace has become more fully understood. The production of silicon, which is of great value to the chemical industry on account of its resistance to the action of acids, was formerly carried on on a very small scale but is now manufactured extensively by electric furnace methods. Many thousands of horsepower are now devoted to the production of ferro-alloys and silicon in the electric furnace. Vertical electrode type crucible or ore smelting furnaces are usually employed for this work.

Smelting of Iron Ores.—The electric furnace is being employed to some extent in the production of pig iron. In Sweden, about 40,000 h,p, are utilized in this industry. The more recently developed processes have proved technically successful, and in localities where fuel cost is high and conditions are such that electric energy can be supplied at low rates, the field

of application of the pig iron furnace is large. The average amount of energy required has been found to be between 1800 and 2000 kw-hr. per ton of iron smelted.

Iron Smelting Furnace at Heroult, Cal. (capacity 2400 kw., 20 tons per day).

Whereas fuel is used in a blast furnace for producing heat for the reduction of iron oxide it is only required in the electric furnace for the latter purpose. The amount of fuel required is therefore at least 70 per cent less and a much inferior quality may be used.

Many types of furnaces have been developed for the smelting of iron ores. They all consist of refractory smelting chambers provided with two or more

electrodes. A shaft mounted above the smelting chamber is filled with ore, flux, and fuel which gradually moves downward as the materials are melted. Heat is produced by the current passing between the electrodes through the charge.

Smelting of Copper, Zinc and Other Metals.—A discussion of the feasibility of producing iron and steel is given elsewhere. The reduction of ores of copper, tin, lead, and other metals, is accomplished by smelting them with fuel. The electrical method may be adopted in a number of places where fuel cost is high and power cost is low as it has been found that the reduction can be carried on more accurately in the electric furnace than in fuel fired furnaces.

On account of the volatility and the ease of oxidation of zinc, serious difficulties have been encountered in the treatment of the ores. The electric furnace method has actually been adopted to some extent and the ores smelted satisfactorily. Great hopes are entertained by authorities on the subject of ore treatment for the electric zinc smelting furnace because of present difficulties with fuel apparatus, and on account of the success already attained with the electric installations.

Production of Graphite and Carbide.—Graphite is produced in the Acheson furnace by subjecting a charge of carbonaceous material (usually ground anthracite coal) surrounding a graphite or carbon core, to great heat. At Niagara Falls, N. Y., several million pounds of graphite are annually produced in this manner.

Carborundum is produced by heating a mixture of coke, silicious sand, salt, and sawdust. The coke is used as a conducting core to start the flow of current. The output of carborundum in 1905 was nearly six million pounds, and about 7,000 h.p. was utilized in its production. It is said that about 7600 kw-hr. are required per ton of carborundum manufactured.

Calcium carbide is produced in great quantities in the electric furnace for making acetylene. It may also be used in the production of calcium cyanamide by

heating it with nitrogen and in the production of ammonia by passing steam over the red hot carbide. The former is of use as a fertilizer and the latter may be made into ammonium sulphate for the same purpose. The total production of calcium carbide in the electric furnace amounted to about 250,000 tons in 1909. Several types of so-called ingot furnaces and resistance furnaces have been developed for this purpose. About 6000 kw -hr. are usually required per ton of product.

Electrolytic Furnace Processes.—When a direct current is passed through a fused salt electrolytic action may take place. The metal of the salt is liberated at the cathode, or negative electrode, whereas the remainder of the salt is liberated at the anode. The principles that apply to the electrolysis of fused salts are similar to those pertaining to the electrolysis of salts in solution. A certain amount of current passed through the fused salt will always produce a certain amount of decomposition and it is therefore possible to calculate the amount of energy required to separate a definite weight of a compound into its elements. When an anhydrous salt is used as an electrolyte a red heat is usually required to bring it to a fluid condition and its electrolysis is a furnace operation. Electrolytic processes may be intended either for purification or the recovery of metals.

Chlorine and caustic soda are made by the use of common salt as an electrolyte, carbon as the anode electrode, and molten lead as the cathode. The clorine collected at the anode is used for making bleaching powder, and the sodium liberated at the cathode alloys with the lead, and when treated with steam, combines to form caustic soda.

Metallic sodium is usually made by using the fused anhydrous caustic soda as an electrolyte with a nickel anode and a carbon or metallic cathode. (Casner Process). Other processes for producing sodium direct from salt have been attempted with some success.

Potassium is obtained by electrolytic processes similar to the sodium processes.

Barium, magnesium, strontium, and calcium, are obtained by electrolysis of the fused chlorides.

A method of treating various sulphide ores has been tried out with some success. It is done by decomposing the fused ores of such metals as lead, iron and zinc by the action of chlorine.

Zinc may be obtained from the fused chloride. The furnaces employed are usually provided with carbon anodes and zinc cathodes.

Production of Aluminum. The most important metal that can be commercially produced solely with electricity in the electrolytic furnace, is aluminum. It was originally produced in very small quantities by complicated chemical methods. Prior to the expiration of the Hall patents the manufacture of aluminum in the United States was controlled by the Aluminum Company of America, but since that time other financial interests have taken up its production. Nearly a hundred thousand horsepower of electric energy is in use for this purpose in the United States, although the largest percentage of the world's output is now manufactured in Europe.

The process consists in passing current through melted aluminum compounds. The electrolytic action liberates the aluminum from the fused compounds and splits up the alumina into oxygen and aluminum. The types of furnaces most generally used consist of carbon lined tanks provided with carbon electrodes which extend from the top and dip into the fused electrolyte. Direct current only can be used in this process. The carbon electrodes are made the positive and the tank the negative terminals.

Electrolytic Furnace Refining.—Although it is entirely feasible to refine metals in the electrolytic furnace, the method has not been generally employed on account of the expense and difficulty of high temperature operation. The principles involved are similar to those of refining in aqueous solutions. The metal to be refined is made the anode and some fused salt of the metal is used as an electrolyte. Upon the passage

of current through the furnace the pure metal is deposited upon the cathode.

Production of Nitric Acid and Nitrates.—The principle on which furnaces for this work are designed is the forcing of air through an enormous arc and removing and cooling the air quickly. The oxygen and nitrogen of the air partly combine to form a very small amount of nitric oxide, the percentage varying with the temperature. The nitric oxide, while cooling, combines with oxygen to form various oxides of nitrogen.

After the gases have cooled they are allowed to react with water in spraying towers, forming nitrous and nitric acid. The former decomposes into nitric acid and nitric oxide. The nitric acid may be marketed, or it may be utilized for dissolving limestone and producing calcium nitrate which is useful for fertilizer.

Three-phase alternating current is generally used in the main circuit of the furnaces now in operation and, in order to maintain a steady arc, resistance or inductance coils are connected in series with it. The latter wastes less energy, but necessarily reduces the power factor of the apparatus. Pressures as high as 5000 volts are often used. A magnetic field produced by a direct current electro-magnet supplied with energy from some auxiliary source is often employed to direct the arc upward or downward.

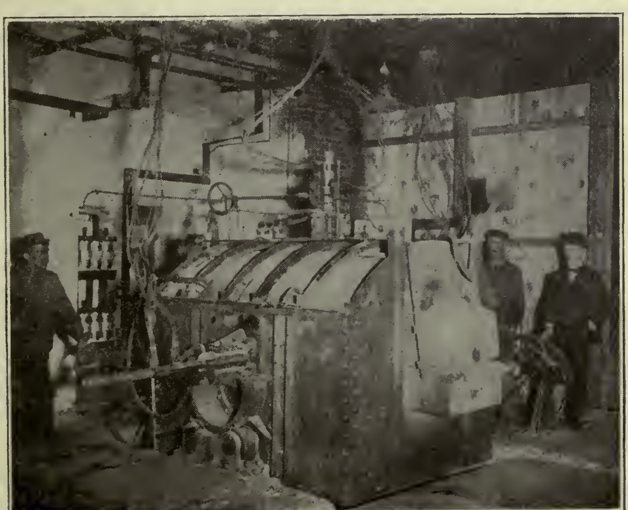
Many thousands of horsepower are utilized in the fixation of atmospheric nitrogen by electric furnace methods, and as the demand for nitrates is rapidly increasing, the industry gives promise of a healthy growth.

Miscellaneous Electric Furnace Products.—Glass may be melted to advantage in the electric furnace. Alundum, which is used as an abrasive, may be made by fusing bauxite in an electric furnace and cooling slowly. Quartz used for making laboratory crucibles, dishes, tubes, etc., may be fused in the electric furnace. The production of phosphorus, which can only be handled away from the air, is readily made in the electric furnace by heating mineral phosphates or bone ash

with carbon and silica. Monox, a substance used in inks and paints, is produced in the electric furnace from silicon and oxygen. Carbon-bisulphide, made by passing sulphur vapor over hot charcoal, is a liquid used as a solvent for oil and rubber, and being volatile, it is sometimes employed for producing poisonous gases.

Production of Electric Furnace Steel.—The use of electricity in melting and refining steel is entering upon a period of rapid growth. The development of commercial apparatus has passed beyond the experimental stage as proven by the fact that there are now over three hundred such furnaces in actual service, about seventy of which are located in various parts of the United States. Since there are between thirty and forty million tons of steel produced annually in this country by fuel methods, the opportunity for introducing electric furnaces is great.

Advantages of Electric Steel Furnace.—As far as cost is concerned, it is unquestionably cheaper to produce the highest quality steel in the electric furnace. For large quantity production of the lower grades of



Rennerfelt Steel Arc Furnace.

steel, it is sometimes possible to make the steel cheaper by fuel methods. For small quantity production the cost is always in favor of the electric furnace. This situation opens up a wide field for relatively small furnaces having a capacity for fifty tons per day or less, although they may be obtained in any size or capacity desired.

Electric furnace steel may be made to any analysis or specifications. Purity of steel is a mark of quality and it is now recognized that electric furnace steel is the purest that can be produced. Among the many superior qualities claimed for electric furnace steel are toughness, greater tensile strength, higher elastic ratio, more solidity and fewer blow holes, higher magnetic properties, and greater malleability. It is coming into great demand for large castings where quality is the first consideration. One great advantage of the electric furnace in the refining of steel is that electricity, unlike fuel, introduces no additional impurities into the molten metal, and a complete charge may be left in the furnace as long as desired without injuring its composition. Impurities, such as sulphur, phosphorus, oxygen, etc., are gradually absorbed in the slag and rabbled off.

Electric Steel Smelting.—Steel may be produced directly by smelting iron ore or indirectly from wrought-iron or pig iron. Whereas the former method is more complicated and has not yet been taken up commercially, it has big possibilities. The reduction of the ore is usually done in the furnace shaft, and the refining in an open hearth or ladle.

Production of Steel from Metals.—The electrical method of making steel from metallic ingredients, known as the indirect method, has proved to be entirely practical commercially and is being rapidly adopted. Pig iron, wrought iron, scrap steel, or mild steel, are melted together in this process and refined to whatever extent is considered necessary.

Resistance Furnaces.—Resistance, induction, and arc furnaces are each used in the steel-making industry. Resistance type furnaces, notably the Gin Steel

Furnaces, are heated by passing a heavy current through the charge under low voltage. The charge is placed in narrow winding channels and the current introduced at each end through water cooled electrodes. This type of furnace has not proven altogether satisfactory in actual service, and later designs provide for heating the charge on the induction principle.

Induction Furnaces.—Heat is produced in these furnaces by inducing a current in the charge placed in one or more annular rings which act as transformer secondaries. A great many advantages are claimed for this type of furnace. In the first place, no electrodes are required and all the difficulties and expense which attend their use are eliminated. The loss of heat by conduction to the outside through the electrodes is obviated. There are no electrode impurities introduced. The steel is contained in a closed receptacle resembling the crucible furnace. The distribution of heat is uniform and the natural circulation set up serves to mix the charge. The heat of the furnace walls and cover is less intense than in the arc furnace and the lining does not wear away so rapidly. Although this type of furnace may create a relatively low power factor, it is much less subject to extreme variations in load than are arc furnaces.

The efficiency of electric transformation in this type of furnace is not high. It is necessarily somewhat limited in capacity because the power factor becomes less as the size is increased unless the frequency of the current is correspondingly reduced. Pressures as high as 6000 volts may, however, be applied directly to the furnace, thus obviating the necessity of providing special transformers, unless the power is to be transmitted a considerable distance.

Types of Induction Furnaces.—The Kjellin furnace is of the single-phase type, and consists essentially of an iron core around one leg of which is wound a primary winding, enclosed in a refractory core and cooled by forced draft or water jackets. The hearth surrounding the coil is provided with an annular groove in which the charge is placed. The furnace is

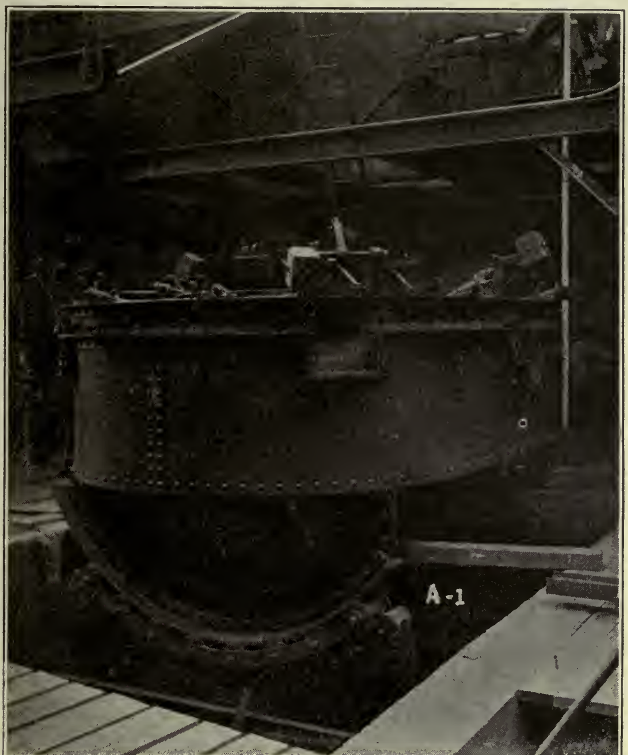
usually built in a circular iron casing which is lined with firebrick. The annular trough is surrounded with a more refractory material such as dolomite or magnesite bricks.

The Colby furnace is similar in principle to the Kjellin furnace. It consists of a laminated iron core around which is wound a copper tube primary cooled by circulating water. The annular crucible secondary surrounds the primary winding. It is claimed that this design operates at a much higher power factor. The character of the primary winding requires the use of lower potentials. It has proved successful in small designs but has not as yet been developed in large sizes. The Frick furnace resembles the Kjellin furnace, but is generally designed for two-phase operation.

The Rochling-Rodenhauser furnace is so designed as to obviate two of the most objectionable features of other induction furnaces. It is provided with a distinct open hearth so that refining possess may be carried on in the furnace, and is designed to operate in larger sizes and at higher power factors. This furnace is built for either single or three-phase operation. In the single-phase type two annular troughs, surrounding two separate sections of the primary coil meet in the center of the furnace and are there expanded into a much larger chamber. The three-phase type is provided with three annular troughs, surrounding three separate single-phase windings. These troughs also converge in the center into a much larger chamber.

In order to maintain the heat in the enlarged chamber a separate secondary winding, of a few turns of heavy conductor, is connected with iron pole pieces imbedded in the furnace walls at opposite sides of the chamber. When the furnace walls heat up they conduct current from these pole pieces through the charge, and thus form a closed circuit for the induced currents and an auxiliary means of heating the charge in the chamber. This winding also serves to neutralize the great self-induction produced by the charge,

and a far better power factor is obtained than in the Kjellin furnace. The use of three-phase types has the advantage of causing a circulation of the charge due



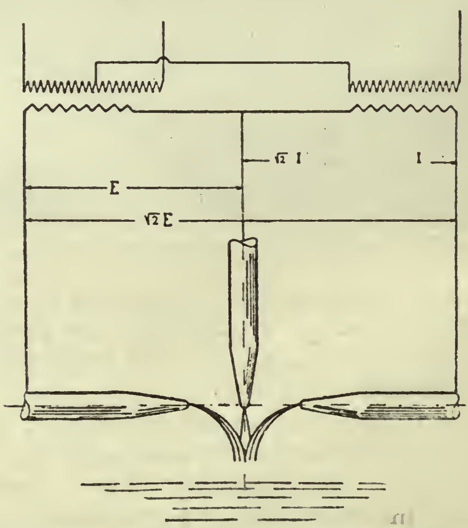
Rochling-Rodenhauser 2-Ton Induction Furnace.

to the rotary magnetic field set up and results in a more uniform product. Both single and three-phase types are provided with lateral doors and arranged for tilting to pour steel and slag.

Arc Furnaces.—The usual classification of steel arc furnaces are (1) independent arc, (2) direct heating arc, and (3) direct heating series arc. There are a number of advantages of the arc furnace over the induction furnace in steel making. They may be started with a cold charge more readily. There is, however,

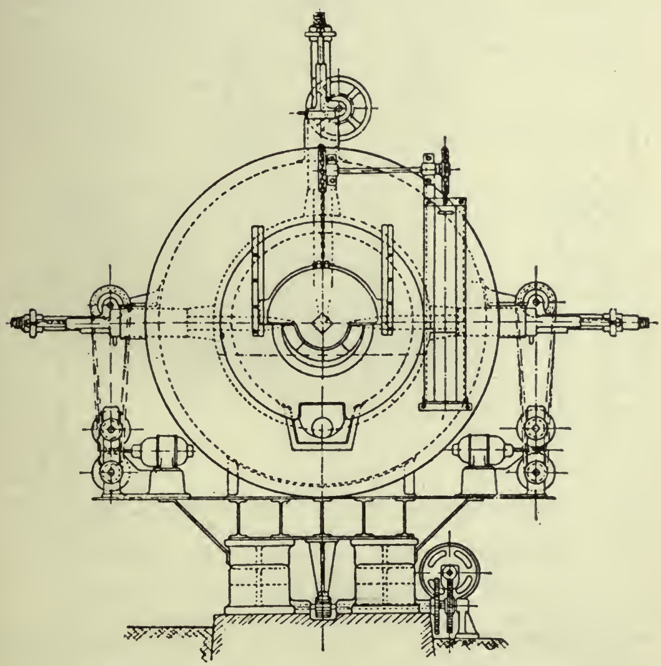
considerable loss of heat which is conducted to the outside through the electrodes. The slag is obviously heated hotter than the metal and as the impurities are absorbed in the hottest portion of the charge the arc furnace is well adpated to refining purposes. These furnaces are also less complicated in design and have a lower first cost. The power factor of the load is much higher than that produced by the induction furnace, and the necessity of utilizing special frequencies in the larger sizes is less marked. The load is, however, subject to wide variations, especially in the direct heating are furnaces when cold scrap is melting down or flux is thrown into the chamber. Either direct or alternating current may be used in the arc furnace.

Under average commercial conditions arc furnaces show better cost results in heating cold metal than in heating molten iron from a fuel furnace. Combustion melting introduces impurities from the metal, oxygen and nitrogen from the blast, and sulphur from the fuel.



Electrode and Connections of the Rennerfelt Arc Furnace.

Independent Arc Furnaces.—Heat is produced by one or more arcs above the charge in a refractory chamber in this type of furnace and the steel is heated by radiation from the arc. The Stassano steel making furnace is an example of this class. It usually consists of a chamber lined with magnesia blocks and three electrodes supported from the sides at an angle of about 15° with the horizontal. It is mounted on trunnions and may be tilted for skimming the slag or pouring the metal. The length of the arcs drawn may be regulated at will and movements of the charge do not vary the load. It is said that the load is almost non-inductive and very steady.

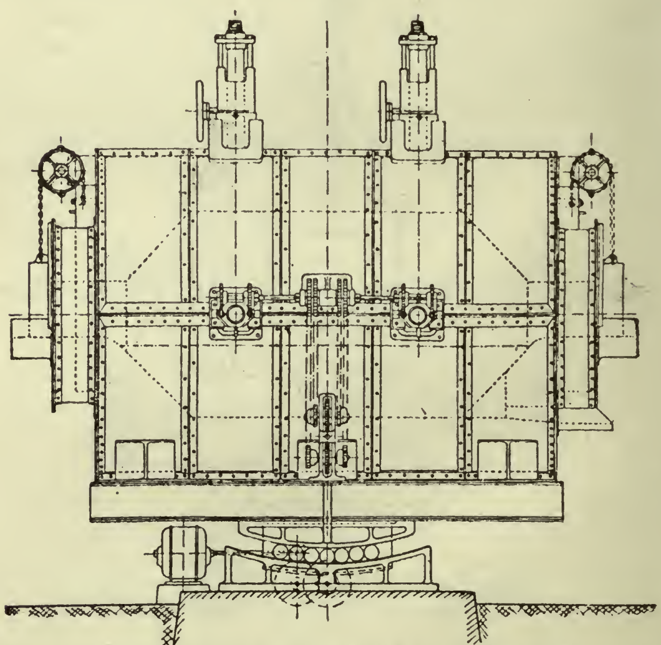


End View of a 12-Ton Rennerfelt Furnace.

Types of Independent Arc Furnaces.—The Stassano furnace in types similar to that described above was the forerunner of the Rennerfelt. The former

started with a radiating arc, playing almost horizontally over the bath, whereas the latter furnace forces the flame down on the charge by employing a special electrode arrangement.

Polyphase current of any frequency or voltage may be used but three-phase current is generally supplied to the transformers and changed by means of the Scott connection to two-phase three-wire current at 70 to 110 volts. One electrode enters centrally through the roof and two horizontally through the sides. The diameters of the electrodes varies from 1½ in. for the small sizes up to 4 or 5 in. for the large sizes. The middle or combined electrode carries about 40 per cent more current than either of the side elec-



Side View of a 12-Ton Rennerfelt Furnace.

trodes. If direct current is used the horizontal electrodes are coupled in parallel, whereas the vertical electrode is connected with the other pole.

The furnace is generally built with a horizontal cylindrical steel shell, supported on rollers or trunnions with one charging and casting door on the side or in the end of the furnace. The shell is lined with asbestos board, next to which firebricks are built in rings. An acid or basic lining is then placed over the firebricks.

The electrodes in the smaller furnaces are manually operated, whereas they are automatically regulated in the larger types. It is not necessary to adjust the horizontal electrodes during the furnace operation.

Direct Heating Arc Furnace.—The charge forms one pole of the circuit in this type of furnace and is thus heated directly as well as by radiation. The simplest types consist of an enclosed chamber lined with refractory material and provided with two electrodes, one at the top which is adjustable and one which is fixed in contact with the charge at the bottom. The arc is made to play between the upper electrode and the charge.

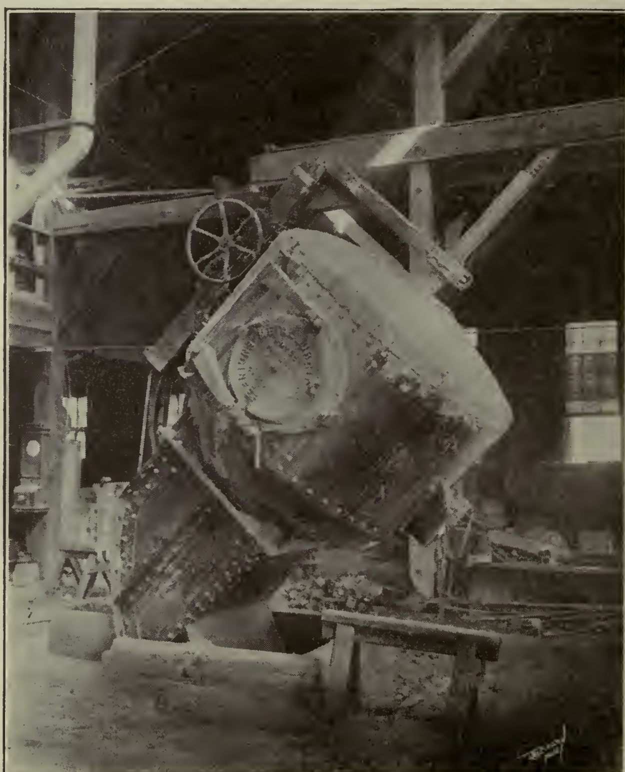
Types of Direct Heating Arc Furnaces.—The Girod furnace is a typical example of the direct heating arc furnace. It is provided with one or more adjustable carbon electrodes of one polarity supported from the top. The lower electrodes are made up of a number of iron or steel bars passing through the bottom of the furnace and making contact with the charge. The casing is of iron or steel lined with magnesite or dolomite. The cover is lined with silica bricks and may be lifted off. The furnace is made round, or square with rounded corners. It is easily operated, and the electric current, which passes through the entire charge, makes it heat quickly when started cold.

The Keller steel furnace is similar in principle to the Girod furnace, although differing somewhat in design.

The "Electro-Metals" steel furnace is usually designed for two-phase operation. It is provided with two adjustable carbon electrodes which enter through the roof. A permanent carbon electrode in contact with the metallic shell is built into the bottom of the

furnace. The magnesite lining covers the bottom electrode completely. One phase is connected to each top electrode, and the other pole of each phase is connected to the bottom electrode. When the furnace is started cold, current passes between the two upper electrodes through the metallic charge. As soon as the lining is heated it begins to conduct current from the bottom electrode through the charge to each top electrode. This furnace will operate more steadily than the Girod or Keller because if one arc is broken the whole supply of energy is not cut off.

The Snyder steel furnace is of the single electrode direct heating arc type and has met with con-



Snyder Steel Furnace.

siderable favor. There are about 15 of these furnaces in use in the United States and Canada at the present time, varying in capacity from 6 to 30 tons of steel castings per 24 hours. Several furnaces are being used for smelting ferrosilicon, one for melting brass and seven for special chemical work.

Series Arc Furnaces.—As the name implies the direct heating series arc furnace has two or more arcs in series. The current passes from one electrode through an arc to the charge and from the charge through another arc to another electrode. The hearth is usually made of burnt magnesite or similar material.

Types of Series Arc Furnaces.—The Heroult is the best known example of a series arc steel furnace. It has made the most favorable impression in this country, as evidenced by the fact that there are now about forty in use in the United States. It is usually lined with dolomite brick next to the casing with an interior lining of crushed dolomite. The roof is made of silica brick covered on the outside with a steel casing. The two electrodes are cooled with water jackets, and are each automatically adjusted by the variation of the furnace voltage.

The operation of a five-ton Heroult furnace is shown in some data prepared by Professor Eichhoff of Charlottenburg:

Generator Capacity.	Condition of Charge.	Length of Heat.	Kw-hr. per ton.
750 kw.	Cold	6.05 hr.	725
750 kw.	Cold	6.63 hr.	795
750 kw.	Cold	7.22 hr.	868
643 kw.	Hot	2.57 hr.	265
643 kw.	Hot	3.15 hr.	324

The Keller furnace is another type of series arc direct heating furnace. It is provided with four carbon electrodes and may be used for single, two or three-phase operation.

CHAPTER XII

LOW TEMPERATURE ELECTRIC FURNACES AND OVENS.

Field of Application.—Aside from the electric furnaces used in electrochemical and electro-metallurgical processes there are many other electric oven and furnace applications designed for industrial heating operations which require relatively high, moderate, or low temperatures. The possibilities for applying electric heat in this manner are so many and varied that only a small percentage of them will be considered. The various processes will be classified with reference to their temperature requirements and to the kind of work which they are intended to accomplish.

Advantages of Electric Operation.—The points of superiority of electric furnaces to fuel furnaces are numerous and vary considerably with the character of the work to be performed. Some of the obvious advantages are the elimination of fire and explosion hazards. The danger of overheating or burning the charge is also removed. For tempering, forging, hardening, annealing, etc., the uniform heat obtainable is ideal. The reduction in scale formation during the heating of tools, saves the metals and insures a better finished product. Unlike fuel equipment, the electric furnace gives off little heat to the surrounding atmosphere and the working conditions are therefore far more satisfactory in hot weather.

Furnace Processes.—Resistance furnaces may be used for vitreous enameling, for heating bolt and rivet stock, for welding and forging steel parts, for hardening high speed steel, and for melting such metals as copper and gold. The temperatures required for this work may vary from 1800° to 2500° F. Furnaces oper-

ating at temperatures from 850° F. to 1800° F. are often used for (1) case hardening, (2) annealing brass, copper, malleable iron, carbon steel and high speed steel, (3) hardening some high speed steels, and carbon steel, (4) melting aluminum, silver, zinc, etc. Temperatures varying from 500° F. to 850° F. are often employed for boiling varnishes, heating oil tempering baths, sherardizing, some forms of annealing, and for

General Electric Type RHF 25 kw. Hardening Furnace Outfit.

melting lead, tin, babbitt, etc. Temperatures of from 200° F. to 500° F. are utilized for heating cores, vulcanizing, drying impregnated woods, and baking enamels, lacquers, japans, insulating compounds, etc. Lower temperatures may be employed for various drying purposes, bacteriological processes, incubation, etc.

Carbon-Resistance Type Furnaces.—For temperatures ranged from 850° F. to 2500° F. this type of furnace is often used. The walls are usually constructed of fire brick supported on iron framework. The heating chamber is lined with refractory material and equipped with a main and an auxiliary resistor. Powdered coke is the main resistor and is laid to a

depth of several inches upon the furnace floor. The roof is the auxiliary resistor. It is made of special refractory material that becomes an electrical conductor when heated to a high temperature. Both the main and auxiliary resistors are in contact with the carbon electrodes at opposite sides of the furnace. By controlling the ventilation in this type of oven an oxidizing, neutral, or reducing atmosphere may be secured. If the ventilation is cut off, the oxygen in the air combines with the carbon. Neutral and reducing temperatures are essential in the treating of various metals and the value of electric operation is therefore apparent. These furnaces are usually controlled by thermostatic devices which operate relays and switches mounted on main control panels.

Another type of carbon resistance furnace consists of two piles of flat carbon plates on opposite sides of the furnace. The two sets of resistors are usually connected together at the top and current introduced at the two lower ends by means of heavy carbon electrodes. Heat is generated by the resistance which the carbon plates offer to the flow of electric current. The Hoskins Company manufactures small crucible, muffle, and drill furnaces of this type. It also makes carbon resistance tube furnaces using carbon rings to which energy is supplied from opposite ends of the tubes.

Metallic Resistance Type Furnaces.—For producing any desired temperature up to 1800° F. the heating units may be made of metallic resistance material. They are adaptable to all kinds and classes of work where a clean, dry, uniform heat of low or moderate temperature is required. There are so many different designs of metallic resistance furnaces, which depend upon the class of work for which they are to be used, that only a few will be described. They are usually controlled thermostatically. The heating elements may be in the form of grids or coils of wire.

Some of the industrial processes that may be performed with electric heat, and the temperatures required are given in the accompanying table:

Process.	Temperature Range. Deg. F.
Baking of japan	300- 600
Baking of varnish and paints	100- 300
Baking color enamels	100- 300
Baking foundry cores	350- 500
Baking insulations	200- 500
Annealing copper	350- 700
Annealing aluminum	500- 800
Annealing glass	900-1000
Tempering steel	200-1000
Melting lead	620- 700
Melting tin	450- 500
Melting babbitt	450- 700
Wax and compounds	150- 500
Heating coils	100-1000
Heating metal molds	200-1000
Lumber drying kilns	100- 200
Boiling varnishes	150- 500
Soldering	400- 650
Glue pots	100- 200
Melting type-metal, linotype machines	625- 700
Sheradizing	650- 700

Furnace Selection.—In order to select the proper type of furnace for any kind of work it is necessary to know the temperature to which the material is to be heated, the number of pounds and character of material to be treated, the weight and dimensions of each piece, and whether the material is to be melted, forged, hardened, tempered, or annealed.

A furnace should be selected of the proper kilowatt capacity and dimensions for the work in hand. Its thermal efficiency should be high, and it should be designed as nearly as possible for continuous operation at its maximum capacity in order to insure economic and satisfactory results.

Enameling Ovens.—The extremely rapid progress that has recently been made in the utilization of electricity for baking enamels, lacquers, japans, etc., has opened up a very wide market for central station power. After making careful preliminary investigations into the relative merits of fuel and electric enameling ovens the Overland Automobile Company has installed 6000 kilowatts capacity in enameling ovens having a total content of 50,000 cubic feet. The Ford Company has also arranged to equip a large number of ovens with electric heaters at its main factory and at its various assembling works throughout the country. Both concerns have remodeled fuel ovens, instead of waiting to build new electric ovens, which is con-

clusive evidence of their confidence in the superiority of electric operation. A number of other large concerns are arranging to take similar action.

Japan Baking Oven.

Advantages of Electric Enameling Ovens.—Electricity supplies a clean, dry heat that is under positive control and uniform in all parts of the oven. The radiant heat drives off the water vapors, produces no additional moisture, and gives off no harmful products of combustion. The enamels have a finer finish, and brighter gloss, are of better quality, and can be turned out with greater speed than with any type of fuel equipment. The hazard from fires and explosions is also reduced by electric operation.

In baking enamel it is important to drive off the water vapors and to oxidize the enamel film in order

to secure a bright, fine finish. Each cubic foot of gas burned in a fuel oven throws off two cubic feet of water vapor which constantly adds to the moisture to be removed. In the gas oven the oxygen of the air is consumed very rapidly thereby retarding the oxidation of the enamel film. The excessive ventilation required in the gas oven to remove moisture and other

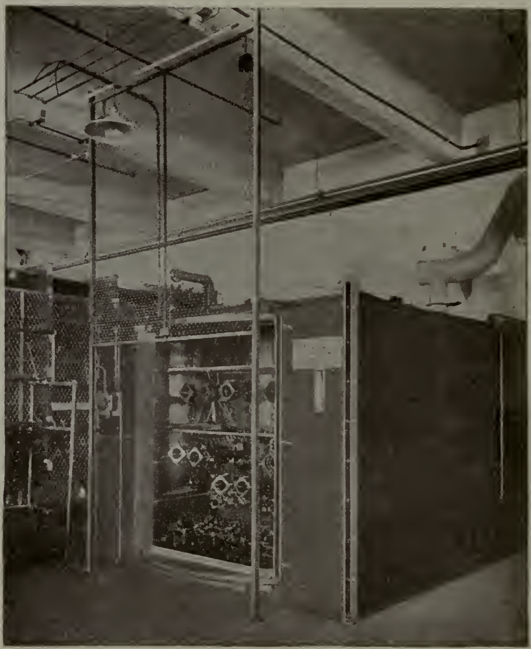
Drying and Baking Oven Loaded.

products of combustion, and to supply sufficient air for the proper oxidation of the enamel film, not only carries away great quantities of heat but picks up dust particles from the outside air which are deposited on the soft enamels.

The radiant heat supplied by the electric method is distributed uniformly throughout the oven whereas the fuel heat is likely to be more intense at the top

than at the bottom, especially when rapid ventilation has to be provided. The danger of overbaking is entirely done away with in the electric apparatus. The labor cost is reduced, and the ovens being thermostatically controlled, no watchmen are required at night.

Steam heat cannot be used for high temperature enameling on account of the excessive steam pressures required. In order to attain a temperature of 400° F. for instance, a steam pressure of at least 250 pounds is necessary.



Combined Steam and Electric Japan Baking Oven (One compartment being loaded and the other baking).

Greater Production.—Electric ovens have been found capable of turning out from 40 per cent to 60 per cent more product than other types. Practically all the available thermal energy is directly applied to useful work in the electric oven. It may be operated at

very nearly the limit of safe operating temperatures without fear of destroying the product.

Although, in some cases, the total cost of electricity for heating an oven is greater than where fuel is used, the improvement of the work, and the increased output, usually warrants its adoption.

Characteristics of Enamels.—Different grades of enamel are required for different classes of work. They vary in their analyses and in their baking treatment. Some harden at low temperatures, and others will stand relatively high temperatures. Some material to which enamel is applied, will not stand high temperatures, whereas other material may be heated

A Set of Drying and Baking Ovens.

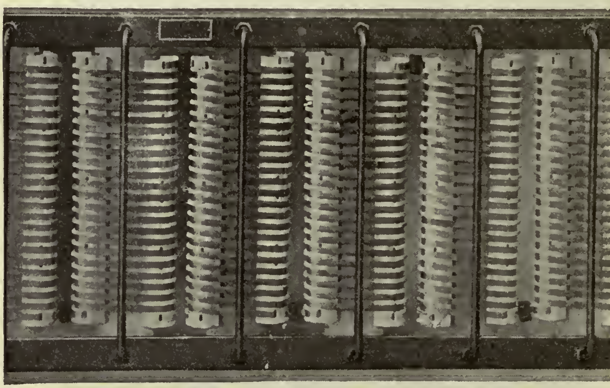
as hot as the enamel will permit. Three or four hours' application of heat at 160° F. will dry Japans that require twenty-four hours or more to harden. Enamels that will bake in 45 minutes at 500° F. require from four to five hours when the temperature is maintained at 300° F.

The greatest economy is derived from the use of high temperature enamel. By bringing up the temper-

ature rapidly, and doing the work quickly, convection and radiation losses are reduced.

Equipping Fuel Ovens for Electric Heat.—An oil or gas fired oven may be fitted with electric heaters by replacing the burners and other fixtures with electric units. If the old oven is not thoroughly insulated against heat losses it should be reconstructed to insure satisfactory operation. The ventilation of the oven should be reduced, and arrangements made to cut it off entirely after certain temperatures are attained.

There are several kinds of enameling ovens designed for electric heat. They are all thoroughly insulated against heat losses. The units may be placed on the floor, or mounted on the walls, depending upon the size of the oven, and the shape and quantity of the work.



General Electric 400 Volt Oven Heating Unit.

Revolving Type Ovens.—In this type of oven the work is pushed into the oven on a carriage, and while one charge is baking the side opposite may be loaded. It is revolved by a motor attached to a worm gear. The space taken up by this type of oven is relatively small, and it does not have to be cooled down each time a charge is inserted.

Drying Ovens. — Electric heat has been successfully employed for drying varnishes. In practice,

ovens varying in width from 12 to 18 ft., and in length from 15 to 35 ft., are usually employed. The dryers are designed with wood or iron frame works covered with fibre board, sheet iron, wood and asbestos, in a way to build up dead air spaces and retain the heat. Thermostatic control devices, for maintaining uniform temperatures, are usually provided.

The average temperatures required inside the dryers for securing the best results are as follows:

	Deg. F.
Varnishes on wood	110 to 125
Varnishes on metal	110 to 130
Stains on wood	100 to 125
Fillers on wood	110 to 125
Primers on wood	115 to 125
Primers on metal	120 to 140
Rough stuff on metal	120 to 140
Enamels on metal	140 to 170

The maximum temperatures should be avoided unless the woods are free from moisture and easily softened ingredients.

The periods required for drying various coatings subjected to the above temperatures are approximately as follows:

	Hours.
2 and 3 day varnishes require	3 to 6
4 and 5 day varnishes require	4 to 7
5 and 6 day varnishes require	4 to 8
7 and 8 day varnishes require	6½ to 10
Fillers require	4 to 6
Water stains require	2 to 2½
Rough stuff requires	2½ to 3½
Primers require	4 to 8

The most desirable humidity to maintain during operation varies with the varnish composition. Some quick drying varnishes require no artificially produced moisture, whereas others need it to retard surface drying. Premature drying often interferes with the evaporation of volatile elements and the necessary penetration of oxygen into the coating. Simple devices for adding moisture to the air may be obtained.

Heat Losses Through Oven Walls.—Some interesting tests of thermal insulation of electric ovens printed in the Electrical World of May 27, 1915, page 779, afford information of considerable value to the oven designer. The apparatus used consisted of a specially constructed double walled oven having in-

terior dimensions 34½ in. wide, 35½ in. high and 55⅞ in. long. The walls were made of half-inch asbestos board, calked with 85 per cent magnesia plaster, with a space between the inner and outer walls of approximately two inches. Six kilowatts capacity in heaters, arranged for a wide range of load, were installed in the inner chamber. Careful tests of heat losses were made under the following conditions:

(1) With the outer walls removed.

(2) With the outer walls in place, leaving an air space between the inner and outer shells.

(3) With three wooden strips on baffle plates placed horizontally between the walls around the entire oven dividing the space between the shells into a series of four air spaces.

(4) With the space between the walls packed with cotton waste.

(5) With the space between the walls packed with mineral wool.

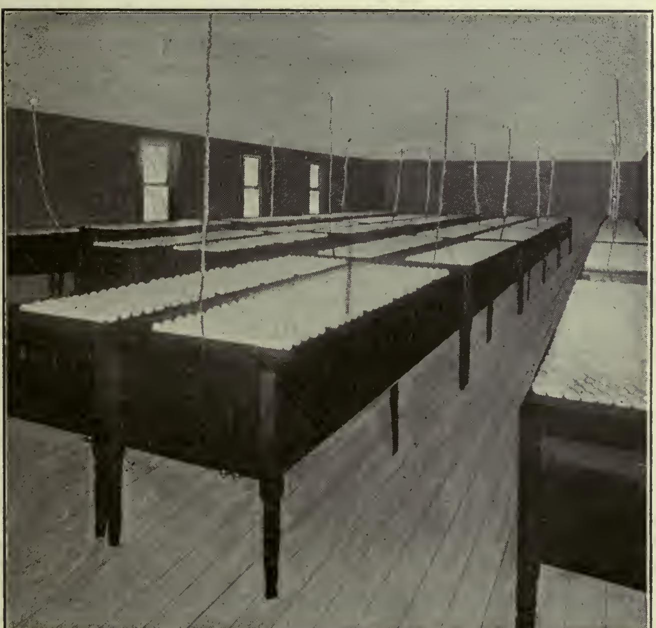
The tests of course indicated the greatest losses with the outer shell removed. The use of the outer wall increased the efficiency about 60 per cent. The baffle plates used in the third test had no appreciable effect. The cotton waste improved the thermal efficiency nearly 50 per cent and the mineral wool nearly 90 per cent. A summary of the results obtained is shown in the table.

Test.	Nature of Wall.	Thermal Resistance Rating.
1	Single shell	1
2	Double shell and simple air space	1.62
3	Double shell and cellular air space	1.62
4	Double shell packed with cotton waste	2.38
5	Double shell packed with mineral wool	3.07

CHAPTER XIII

INCUBATING AND BROODING.

Modern Methods.—Although artificial incubating and brooding has been practiced for many years in Europe, Asia, and the United States, the latter country has been most progressive in developing means for utilizing electric heat as a substitute for heat produced by fuel combustion methods. The superiority of electricity is quite obvious to anybody familiar with the poultry business. The number of fuel heated incubators and hovers in use in this country reaches



Portion of White Hatchery, Petaluma, Cal.
(Capacity 40,000 eggs.)

well into the millions, but the vast field which the application of electric heat to these devices has opened up for the manufacturer of heating apparatus and the distributor of electric energy is little appreciated. In one small town in California about 10,000,000 chicks are hatched annually by artificial means. The hatching and brooding of these chicks would require about 3,000,000 kw-hr. per year, if electric operation was substituted for fuel.

The character of the load is desirable from the standpoint of the central station. The machines are non-inductive, and the diversity factor is naturally high. Where a large number of machines are in use the load is not one that varies greatly with the season of the year as might be supposed.

The processes of incubating and brooding are outlined in order to convey a clearer appreciation of the advantages afforded by the application of electric heat.

Poultry Incubating.—All kinds of eggs may be hatched by artificial means. The period of incubation varies with the kind of egg and with temperature conditions. If the heat has been maintained at too low a temperature during the period of incubation, or if the eggs have been chilled or overheated, the hatching may be delayed somewhat.

The average incubating periods of various kinds of eggs by both natural and artificial methods are as follows:

	Days.
Hen egg	21
Pheasant egg	23
Guinea egg	27
Duck egg	28
Peafowl egg	28
Turkey egg	28
Goose egg	32
Duck egg (Muscovy)	34
Ostrich egg	42

The hatching of chickens by artificial means is perhaps most commonly known, and is therefore described.

Incubating of Chickens.—The eggs are placed on portable trays at an angle of about 45 degrees, with the small ends down, leaving the air cells in the large ends. These trays are then placed in the incubator,

and the temperature brought up gradually to 102° F., and maintained at that point for from four to six days, when a test is made. This test consists in holding the tray of eggs to the light. If they are fertile the operator will observe a spider like shadow within the eggs, showing that they are germinating. The eggs that are not fertile will be perfectly clear, and will be removed from the tray. Another similar test is often made about the fourteenth day. After the first test is made, the temperature is usually brought

Petaluma 200 Egg Incubator.

up to 103° F. and maintained at that point until the hatch is off. The temperature is always taken with the bulb of the thermometer even with the horizontal plane of the eggs.

After the eggs have been in the machine about seventy-two hours, they are cooled daily by removing the trays from the machine for from one-half hour to two hours, depending upon the temperature of the

incubating room. When they have cooled to about the temperature of one's body, (which may be observed by holding one of them against the cheek), they are put back in the machine. The eggs are cooled to allow the germ to rest, for otherwise the chick when hatched would be weak and nervous. Each time the eggs are cooled they are turned at a different angle, but the small end is always kept pointing downward.

Esco 100 Egg Incubator.

Constant observations are made to see that the egg is drying down properly. By the eighteenth day the air cell in the large end should be dried down to about 30 per cent of the total volume of the shell. To hasten the drying process, ventilation may be increased provided no drafts are produced. In case the eggs dry down too rapidly, the bottom of the incubator may be sprinkled, or a slight spray of water given the eggs.

After the eighteenth day the incubator is closed until the chicks are taken off. A slight film of moistture, on the lower edge of the inside glass, usually indicates that the air is of proper humidity for "pipping." As the chicks "pip" through their shells, they drop through the trays to the space below, known as

the nursery. After they are about twenty-four hours old, they are removed to the brooders.

Electric Incubators.—These appliances usually consist of square or oblong cases mounted on wooden supports. They may be double walled with shoddy, mineral wool, asbestos, or other heat insulating material interposed, or single walled lined with heavy paper. Tight fitting double doors, the inner one always of glass, are provided along the front for examining the interior and moving the egg trays. These trays are made of either wood or metal and are inserted in the machine about four inches from the bottom. The heating elements are usually mounted near the top of the egg chamber, although in some makes of double deck incubators heating elements are placed near the bottom, as well as at the top.

Electro-Hatch 200 Egg Incubator.

Single deck types are claimed to be more satisfactory than double deck machines, on account of the more uniform heat that may be applied on a single plane. On the other hand, the double deck type re-

quires less energy for heating a given number of eggs. In the single deck types provided with top heating units, the temperature is naturally higher above the eggs, and lower below them. The temperature in the nursery below the trays is therefore maintained at about 95° F., which is considered most desirable for newly hatched chicks.

The thermometers used in incubator work should be high grade instruments, because it is essential to know at all times just what temperatures are being

Esco 200 Egg Incubator.

maintained. A slight error in the thermometer will have a large influence on the success of the hatch.

Most of the thermostats that have been developed for use with electric incubators are extremely sensitive and are capable of maintaining the desired temperature to within ¼° F. to ½° F. These devices should be simple in construction, positive in action, and absolutely reliable, in order to insure the best results.

A well constructed single deck machine is generally provided with an average of about 75 watts heating capacity per 100 eggs. The average current consumption has been found to be about 10 kw -hr per

hundred chicks hatched. Incubators are now available that will hold from 30 to 1200 eggs.

Advantages of Electric Incubators.—An incubator heated by coal, oil, or gas is constantly filling the machine with fumes and burning up oxygen so essential to the germ life in the egg, whereas electricity neither destroys good air nor gives off bad air. The temperature control is simple and requires no attention, other than setting the thermostat by turning a thumb screw a couple of times during the hatch. The fire risk is entirely eliminated. The anxiety that attends the operation of fuel heated machines is done away with. The distribution of heat is perfect and the ventilation can be regulated at will. Much time and labor usually required in looking after fuel equipment is saved. The machines may be located in any convenient place and are adaptable to any climate. It is furthermore interesting to note that electrically hatched chicks always begin to pip about twelve hours quicker than those hatched by other artificial means. They are always stronger and more vigorous, and statistics show that a much higher percentage is hatched.

Relative Operating Costs.—The following comparative figures are taken from many averages secured in actual practice. They are based on an assumed incubator room temperature of 60° F. Although a rather low rate for electricity is required to make the actual operating cost comparable with those of some of the less expensive fuels, the savings effected, the better results secured, and the greater degree of satisfaction obtained by electric operation, will usually overcome whatever objection arises as to the cost of producing heat.

Relative Cost of Heat for Incubating.

Method of Heating.	Approximate Cost. Per 100 Eggs.
600 B.t.u. gas at $1.50 per 1000 cu. ft.	37c
600 B.t.u. gas at $1.00 per 1000 cu. ft.	25c
Coal oil at 20c per gallon	20c
Electricity at 5c per kw.-hr	50c
Electricity at 3c per kw.-hr	30c
Electricity at 2c per kw.-hr	20c

Brooding of Chickens.—The chick which is taken from the incubator to the brooder at the age of twenty-

four hours (and known as a "day old chick") is not fed for another similar period or until the chick is about forty-eight hours old. The reason for this, is that the chick has absorbed the yolk of the egg into its digestive organs just prior to pipping, and continues to live on this food for the entire forty-eight hours. The chick's first meal should consist of grit, such as coarse sand, after which it may be fed some good chick food.

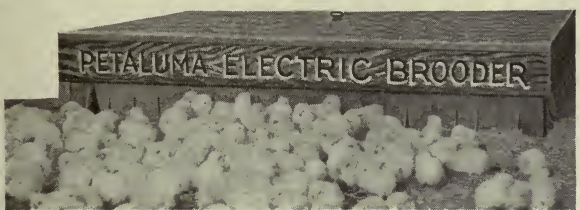
The temperature of the brooder should be kept at about 95° F. for the first week and gradually dropped for the next five weeks or until the chick is sufficiently matured to roost. It is important to watch the temperature carefully with very young chicks, because otherwise they will become restless and crowd together as soon as their backs get cold. If the crowding becomes too severe, the chicks will sweat and become weak and the less rugged ones may be smothered.

A chick demands plenty of oxygen, (about 10 times as much as a person in proportion to its weight), and if it is to mature rapidly and develop good lungs, the brooding must be done in a well ventilated room. The chick should not be subjected to drafts of air, however, and best results are secured in a room having a tight floor and provided with high ventilation. The temperature of the room is immaterial as long as the proper degree of heat is maintained inside the brooder. Coarse straw or sand is usually spread out beneath the brooders.

Electric Brooders.—These devices are built in round, square, or oblong shapes, and in capacities of from 50 to 1200 chicks. The tops of the hovers are usually made of wood insulated beneath with asbestos, and supported on short wood or metal legs. Strips of canvas or oilcloth, wide enough to reach the floor and retain the heat, are fastened around the outer edges, and slitted perpendicularly every few inches to allow the chicks to pass in and out readily.

In the circular type hover, the heating element is placed in the center of the top, and in other types

coiled wire heating elements are arranged around the top, in order to secure a wider distribution of heat. The air, when heated, banks against the insulated top and settles down upon the backs of the chickens. One or more holes are generally drilled in the floor beneath the machines to introduce a proper amount of fresh air inside.



Rectangular Type Chick Brooder in Operation.

The thermostat for regulating the temperature inside the hover is mounted a few inches below the top and adjusted by a screw on the outside.

A well constructed brooder is usually provided with about 100 watts capacity per hundred chicks. The current consumption has been found to average about 20 kw-hr. per hundred chicks.

Esco 100 Chick Hover.

Advantages of Electric Brooders.—Almost all the advantages that apply to electric incubators, apply as

well to electric brooders. They save time, labor, and anxiety. They insure even heat distribution, easily

Round Type Electro-Hatch Hover in Operation.

Electro-Hatch Rectangular Type Brooders in Operation.

controlled temperatures, and elimination of fire hazard. The electric heat neither burdens the atmosphere with

poisonous fumes, nor destroys its oxygen. It has furthermore been demonstrated in actual practice, that an electrically brooded chicken is usually ready for the roost about two weeks sooner than one brooded by fuel heat, and is universally stronger and more vigorous.

Statistics show that an average of less than 50 per cent of the baby chicks placed under the many types

Interior of Brooding House, Baywood Poultry Farm, San Mateo, Cal.

of brooders now in use are raised to the roosts, whereas actual tests made during the past eighteen months with a large number of electric brooders show that the proportion has been raised by their use to better than 85 per cent.

Relative Costs of Operation.—The following will give an idea of the relative costs of fuel and electric

operation of brooders. The data are averaged from many figures secured in actual practice, and are based on an assumed outside temperature of 50° F.

Relative Costs of Heat for Brooding.

Method of Heating.	Approximate Cost per 100 Chicks.
Artificial 600 B.t.u. gas at $1.50 per 1000 cu. ft..	$1.50
Artificial 600 B.t.u. gas at $1.00 per 1000 cu. ft..	1.00
Coal oil at 20c per gallon........................	1.40
Distillate at 8c per gallon........................	.45
Distillate at 8c per gallon (blue flame burner)....	.15
Electricity at 5c per kw.-hr......................	1.00
Electricity at 3c per kw.-hr......................	.60
..Electricity at 2c per kw.-hr......................	.40

It is apparent that, although electric energy may have to be purchased at a low rate to compete with fuel on the basis of actual cost of heat energy, the advantages accruing to the user of electrically heated apparatus will more than offset this added expense.

CHAPTER XIV

ELECTRIC WELDING.

Nature of Welding.—When two pieces of metal are heated to the proper temperature, brought into contact, and united into one solid piece, the process is called welding. The essential feature is that of bringing the pieces of metal to the proper temperature so that they will tend to flow together and cohere. All the processes that have been devised are simply required for producing heat.

Metals may usually be most easily welded when in a plastic condition. Whereas welding processes were formerly limited to such metals as iron, nickel, platinum, and gold, the high temperatures now available have made it possible to weld almost all the metals and a large percentage of the metallic alloys.

Welding Processes.—A general classification of commercial methods of welding may include smith welding, hot flame welding, chemical welding, and electric welding.

Smith welding or forging is the process of joining pieces of metal by hammering them into shape. It is one of the oldest arts, depends for its success on the operator's skill, is usually expensive, and is more adaptable to small than to heavy work.

Hot flame or gas welding has numerous commercial applications and may be used for many kinds of work that cannot be done by forging. The most important methods are the oxy-acetylene, oxy-hydrogen, oxy-pintsch gas, and oxy-blau-gas. As the names indicate, welding heat is produced in each process by mixing oxygen and another gas in suitable burners. The gases are usually compressed and stored in strong cylinders. The various processes may be used for cutting as well as for welding. The principal advantages are less first-

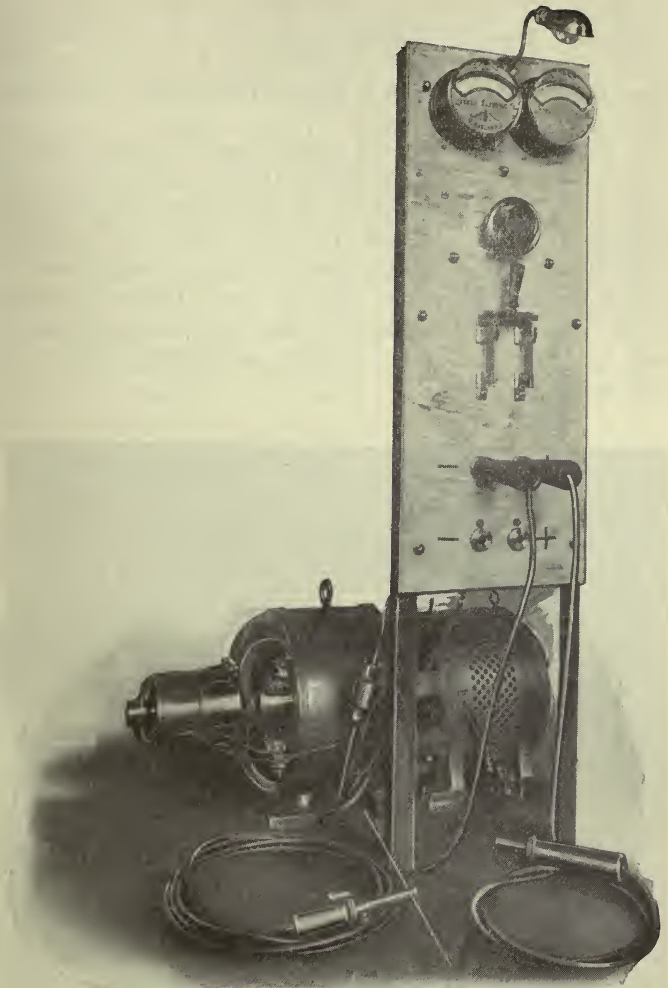
cost, simplicity, light weight, high flame temperature, flexibility, and portability of apparatus. The disadvantages are high operating cost, carbonization, oxidation, cracking of the welds, and danger of fire and explosions from the flames and gases.

Chemical welding is limited in its commercial application to the process known as thermit welding, or "cast welding," which consists in igniting a mixture of aluminum and iron oxide in a suitable mold. The intense heat produced, causes the aluminum to reduce the iron from the oxide, and forms a molten mass of thermit steel which is run into and around the parts to be welded. The process lends itself better to the welding of larger articles than smaller ones, but in any case it is both slow and expensive.

Electric welding, with which this chapter deals, although a relatively new commercial application, is rapidly becoming one of the most important of all the welding processes. The chief advantages are low operating cost, wide range of application, flexibility and ease of temperature control, less harmful oxidation and carbonization, and less expansion and contraction of the parts welded. The disadvantages are higher first cost, and greater weight and lack of portability of apparatus. Electric welding machines may ordinarily be classified, either as arc welding, or as resistance welding apparatus. In the former heat is produced by means of an electric arc, whereas in the latter, heat is produced by the resistance to the flow of current at the contact between the parts to be welded.

Arc Welding.—The electric arc may be used for welding practically all the metals. The commercial processes are usually performed by melting material into openings or crevices, or of fusing down the body of an article to fill such openings. There are a great many practical applications of arc welding apparatus, both in manufacturing and repairing.

Direct current of high amperage and low voltage (usualy 30 to 75 volts) is employed. The amount of current required depends upon the kind of material, size of the weld, and speed of operation desired.



Lincoln Arc Welder (complete with panel board).

Systems of Arc Welding.—There are two important welding processes, known as the Benardos or graphite process, and the Slavianoff or metallic process. In both systems the article to be welded is connected to the positive side of the circuit, and the electrode to the negative side. The arc is produced by

bringing the negative electrode in contact with the work and quickly withdrawing it a short distance. Since the positive terminal of an arc is the hotter, the heat is produced where it can be most effectively utilized.

The graphite process makes use of a carbon electrode. After the arc is drawn, filling material in the form of a "melt bar" is fused into place by the heat produced. This process may be used for welding aluminum, copper alloys, cast iron, and other metals which do not volatilize very readily. The arc should be moved about over the surface to prevent burning, and to cause the slag or other impurities to flow to one side.

Operator at Work With General Electric Arc Welder.

The metallic process makes use of a metallic pencil electrode, (usually iron or steel), which gradually melts from the heat of the arc, and forms the filling material. The current required is much less than for the graphite process but the speed is also less for heavy work. The principal application of this process has been in sheet metal work, where the electrode is deposited along the joints or seams. It is also used for building up worn pieces, and filling holes in castings.

Another system of welding which has not been applied very extensively in this country is the Zerener process, wherein an arc is drawn between two carbon electrodes and deflected downward against the work by a magnet. Its use is limited to light work, but it is claimed that somewhat finer work can be done by adjustment of the magnet.

Arc Welding Apparatus.—In making a choice of equipment, careful consideration must be given to the character of work to be done. All arc welding machinery is designed to take the available energy supply

Repairing Steel Casting with the Lincoln Arc Welder.

and deliver it in proper form for welding work. In the simplest forms of apparatus, the current may be cut down to the proper voltage by the use of either a water rheostat or a heavy resistance connected in series with the arc. When this is done considerable energy is wasted in heating the water or other resistance material.

Low voltage motor-generator sets are often used on account of their higher efficiency and greater ease of control. The generators are usually compound wound, although when used on an individual welding circuit, they may be shunt wound. The compound wound generator gives more accurate voltage regulation and is usually employed where more than one welding circuit is provided with energy from the same machine. Where several circuits are supplied from a single motor-generator set, the current on each circuit must be regulated by the use of special resistances, which naturally causes a waste of energy.

Some welding machines are provided with current through synchronous converters, but the regulation is less satisfactory and they cannot be used as well for finer classes of work.

Generators used for welding are sometimes specially wound for variable voltage operation so that no resistance is required. It is, however, necessary to provide separate machines for each individual operator.

Either graphite or metallic electrodes may be used with practically all arc welding equipments.

Each manufacturer of welding machinery offers its apparatus on the strength of some peculiarity of the controlling apparatus or design of the machines, and the user should consider the class of work to be performed before deciding upon the type of machinery to install.

The current consumption varies with the nature of the material welded, the shape and size of the piece, and the nature of the operation. Metallic welding processes may require from 15 to 150 amperes, and graphite welding from 100 to 700 amperes.

Costs of Arc Welding.—The nature of the work, the cost of energy, and the operator's skill, each have much to do with the cost of welding. It may ordinarily be done in less time and at from 10 per cent to 75 per cent of the average cost of acetylene welding. The following tables show the cost of several arc welding jobs where labor was figured at thirty cents per hour, energy at two cents per kw -hr., and filling material at eight cents per pound. The first table shows the time and cost of welding; the second table, the savings effected over methods previously employed, and the third table the savings effected by repairing electric railway apparatus as against purchase of new parts.

TABLE I.*

Time and Cost of Welding.

Article Welded.	Time.	Cost.
Steel casting, shrinkage crack 6 in. long by 1 in. deep....	8 min.	$00.04
Steel casting, riser, 4 in. by 4 in. cut off..............	4 min.	.05
Forged steel locomotive frame, broken in two places......	20 hrs.	18.28
12 in. crack in back sheet of locomotive boiler..........	9 hrs.	5.47
Building up worn driving wheel instead of turning down....	2 hrs.	.72
Welding 67 cracks in old fire box (saving over $1000)....	2 wks.	52.60
Cast-steel tender frame, broken in three places..........	27 hrs.	19.00
Steel shaft, 2 in. diameter, broken, welded ready to finish..	1 hr.	.60
Broken railway type motor case, cast steel,welded........	3 hrs.	1.95
Enlarged holes in brake levers, steel bars................	4 min.	.05
Building up 2 in. armature shafts, worn in journals......	3 hrs.	1.80
Air brake piston rods, broken, welded ready to finish......	30 min.	.35
Leaking axle boxes, welded in position..................	15 min.	.15

TABLE II.*

Relative Costs of Repairs.

Article Welded.	Welding.	Old Cost.	Saving.
Engine main frames, both broken.........	$11.80	$56.20	$44.40
Driving wheels, built up 3/16 in. on tread..	.72	8.00	7.28
General repairs on fire box side sheets....	66.51	342.62	276.11
Filling worn knuckle joint bushing hole....	.75	7.50	6.75
Welding 7 cracks in locomotive cylinder....	22.35	367.15	344.50
Broken mud ring on locomotive boiler....	32.07	118.06	85.99

TABLE III.*

Street Railway Repairs.

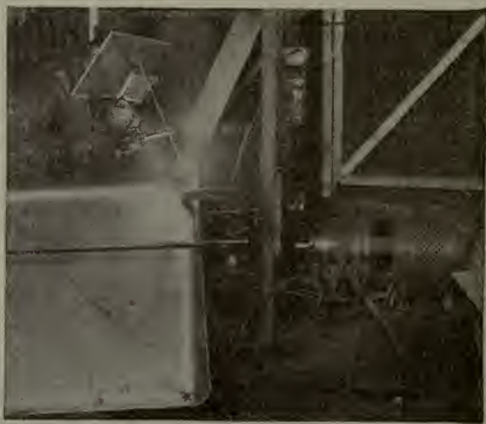
Article Welded.	Welding.	New Part.	Saving.
Armature shaft, repaired in place.........	$1.70	$ 4.72	$ 3.02
Armature shaft, large, repaired in place....	1.97	15.13	13.16
Railway motor axle cap, large............	.22	3.51	3.29
Railway motor armature bearing cap......	.27	6.07	5.80
Railway motor gear case, top half........	.48	7.30	6.82
Truck side frame, Brill 27-G..............	.72	44.40	43.68
Truck side frame, Peckham 14-B..........	.90	46.98	46.08
Brake head, building up worn socket........	.06	1.15	1.09
Motor frame, G. E. 90, railway type motor..	2.88	16.80	13.92

*From "Applied Electrochemistry and Welding."

Arc Welding Operations.—Metallic electrodes are used almost exclusively for thin plate and sheet weld-

ing. The speed at which the work can be done, depends upon the kind and thickness of the material, the kind of weld, etc.

Metallic electrodes are usually employed in welding the seams in tanks, boiler flues, etc. The joints



Seam Welding With Lincoln Arc Welder.

have been found to be much stronger than riveted seams, and the use of electric welding machinery for this class of work is finding a very wide application.

(1) COMPARATIVE COST—ACETYLENE AND ARC WELDING.

	Acetylene		Arc			
Thickness of Metal.	Ft. Welded per Hour.	Cost per Ft. Welded.	Amps. in Arc.	Kw. Input M. G. Set.	Ft. Welded. Per. Hour,	Cost per Ft, Welded,
1/16 in.	25	$0.018	70	3.0	25	$0.014
1/8 in.	15	.047	80	3.2	15	.024
1/4 in.	6	.187	110	4.15	8	.048
3/8 in.	4	.420	120	4.64	7	.056
5/8 in.	2	1.510	150	5.75	6	.070

These data were obtained with a Lincoln welding machine and were based on the following costs:

Acetylene, 1.555 B.t.u..............	1c per cu. ft.
Oxygen	2c per cu. ft.
Electricity	2c per kw -hr.
Labor	30c per hour.

In welding most large iron and steel castings, the carbon electrode and melt bar are employed, although

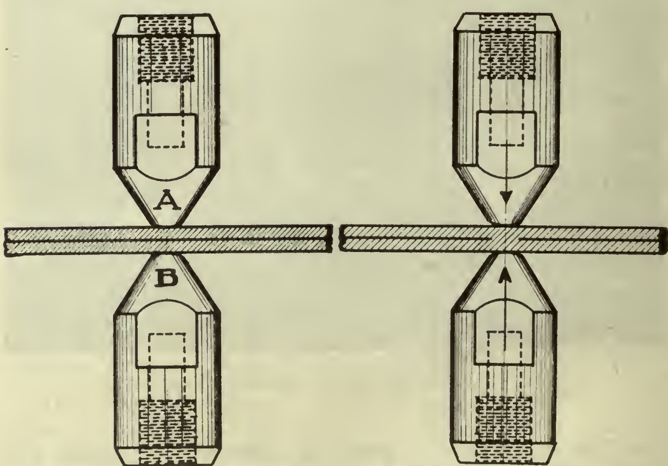
the metallic electrode may be used for light work. A space sufficiently large to work in should be prepared, because the filling material will not flow in small crevices. Cast iron should usually be heated before and annealed after welding in order to prevent cracks, and to soften the weld for machining. The use of a welding flux will ordinarily improve the quality of a cast iron weld by raising the slag.

Welding With the Electric Arc.

The operation of welding aluminum, copper, and various alloys, is somewhat similar to that employed for iron and steel castings. The work is usually placed in a horizontal position and the filling puddled in by the graphite electrode method. Very thin sheets, less than one-eighth inch in thickness, cannot be welded by this means. Larger amounts of current should not be used than are required to melt the metal, and in welding alloys care should be exercised to prevent volatilization of any of the metallic constituents.

Arc Cutting.—The electric arc may be utilized to great advantage for cutting metals in foundries, scrap yards, and similar places. The rate of cutting iron and steel is ordinarily about one square inch of cross section per minute per hundred amperes. The graphite electrode is employed for this work and current varying in quantity from 100 amperes to 1000 amperes may be employed. The electric arc cuts a wider groove than the gas flame, but has an advantage in that it does not destroy the metal that is melted.

Resistance Welding.—This process is quite unlike arc welding. It consists in passing a current through a contact between the metals to be welded. The resistance to the flow of energy being greater at the point of contact, the metals heat up until a welding temperature is attained when they are forced together



Principle of Spot Welding. (Heavy current and pressure applied between A and B cause the metallic plates to heat up and weld at the point of application as shown.)

with sufficient pressure to cause them to adhere. This is usually known as the Thomson system.

Alternating current of low voltage, (usually from 3 to 5 volts), is employed in resistance welding. The work is ordinarily done rapidly, because heavy currents and high pressures may be applied.

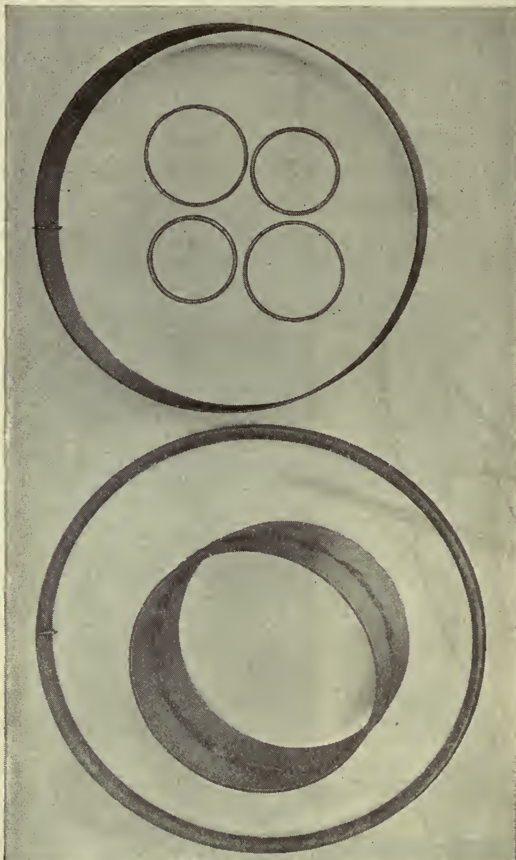
Resistance Welding Apparatus.—The equipment for electric resistance welding requires machines especially adapted to the work in hand. The frame is usually provided with a clamping device for holding the parts, and a means for applying pressure after they have been heated. A transformer for reducing the voltage on the circuit, together with a main control switch, and some means of regulating the flow of current, are ordinarily supplied with the machine.

Manufacturing Applications.—Resistance welding is limited almost exclusively to new work of moderate

Winfield S-12 Spot Welder.

size. Practically every kind of metal, and many alloys and combinations of metals may be welded, if the surfaces can be joined and the parts manipulated in the machines.

A few of the many applications of resistance welding apparatus are as follows:



Wire Rings, Flat Hoop, Small Carriage Tire and Steel Cylinder Welded With a Thomson Welder.

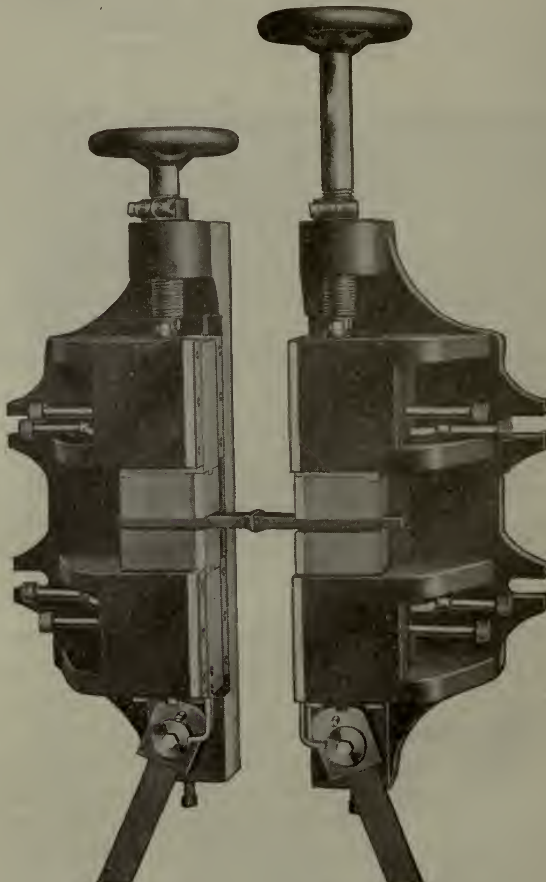
Rail bonds.	Wagon tires.	Iron beds.
Automobile parts.	Shovels.	Wheelbarrow bodies.
Structural iron work.	Iron wheels.	Cooking utensils.
Pipes.	Typewriter parts.	Chains.
Screens.	Stove pipe	Valve heads.
Axles.	Steel shelves.	Knives.
Umbrella rods.	Steel lockers.	Boilers.
Sheaves.		

Classification of Resistance Welds.—The original method was known as butt welding, and consisted in bringing the pieces together either end wise or edge wise. After they became heated they were forced together. A process known as spot welding was afterwards developed for welding lapped joints. It was accomplished by making contact, about rivet size, between the sheets of metal, passing a current through the contact, and applying pressure when the metal became plastic.

A number of other kinds of welds, which, in a more or less degree, are modifications of the butt and spot welds, have found a very wide application. Lap or seam welding consists in passing a current through a lapped seam and applying pressure by means of rolls. Butt seam welding, as the name signifies, is a somewhat similar process. Cross welding for making screens, etc., and tee and jump welding for fastening bars or pipes together, are other common welding processes.

Welding Various Metals.—Although most of the metals may be welded successfully, the commercial application of resistance welding apparatus is usually limited to only a few of them. Iron and steel are most frequently subjected to welding operations, and are about the easiest to handle. The pressure imposed should be high and the metal should be kept below the melting point. Cast iron is very difficult to weld by the resistance process on account of its structure and composition. High carbon steel may be welded, provided it is afterwards annealed to remove the strains. Nickel steel makes a very strong weld. Galvanized iron of moderately thin gauge, may be welded,

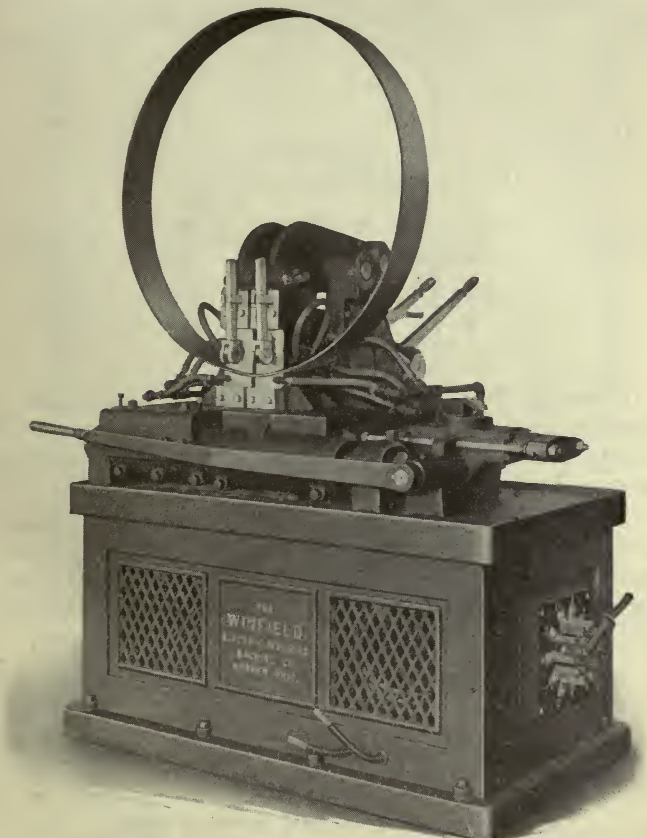
provided the joints are regalvanized when the operation is completed. Sheet aluminum, brass, copper, iron and copper, and brass and copper, may also be successfully welded by skilled operators.



Clamp for Thomson 40-A Butt Welder.

Spot and butt welding operations are limited in the extent to which they can be applied commercially. If the metals are very thick, the amount of energy required will be very large, and the radiation losses from the metals and the cooling water will become excessive.

Character of Resistance Welds.—If the weld is upset so that its cross sectional area is slightly greater than that of other portions of the piece, the joint should have as much strength as the stock. When finished



Winfield BB-255 Butt Welder.

to the same diameter as the stock, it should have a strength efficiency of from 75 per cent to 90 per cent. Ordinarily the strength of a weld may be improved by working. Care should be exercised to prevent heating the material too hot, or the weld may be burnt and thereby weakened.

Butt and Spot Welding Costs.—The average costs of resistance welding are shown in the two following tables, which are figured on the basis of an energy rate of two cents per kilowatt-hour.

Butt Welder Data.

Rd. Iron Diamter in Inches.	Kilowatts Required.	Time in Seconds to Make Weld.	Cost per 1000 Welds 2 Cents per kw.
¼	2	3	0.04
½	5	5	0.14
¾	12	15	1.00
1	18	20	2.00
1½	50	40	11.10
2	75	50	20.84

Spot Welder Data.

Gauges of Sheet Steel.	Thickness in Fractions of an Iinch.	Approximate Kilowatts Capacity.	Time in Seconds to Make a Weld.	Cost per 1000 Welds at 2 Cents per kw.
28	1-64	5	.3	0.009
24	1-40	7	.5	0.02
20	3-80	9	.7	0.035
16	1-16	12	.9	0.06
10	9-64	18	1.5	0.15
6	13-64	28	4.0	0.62

Energy Requirements and Character of Load.—Electric current is usually supplied to the machines at a pressure of 220 volts, which for ordinary welding operations, is reduced to from 3 to 5 volts.

The power required for resistance welding operations depends upon the kind of material, the area of cross section of the pieces, and the time taken for making the weld. The following table shows the average power and time required for butt welding:

Power and Time for Butt Welding Iron and Steel.

Area. Sq. In	Power, kw.	Seconds.	Horsepower.
0.5	10.0	28	13.5
1.0	18.75	40	25.0
2.0	33.00	57	44.0
4.0	56.3	80	76.0
6.0	69.0	98	92.5

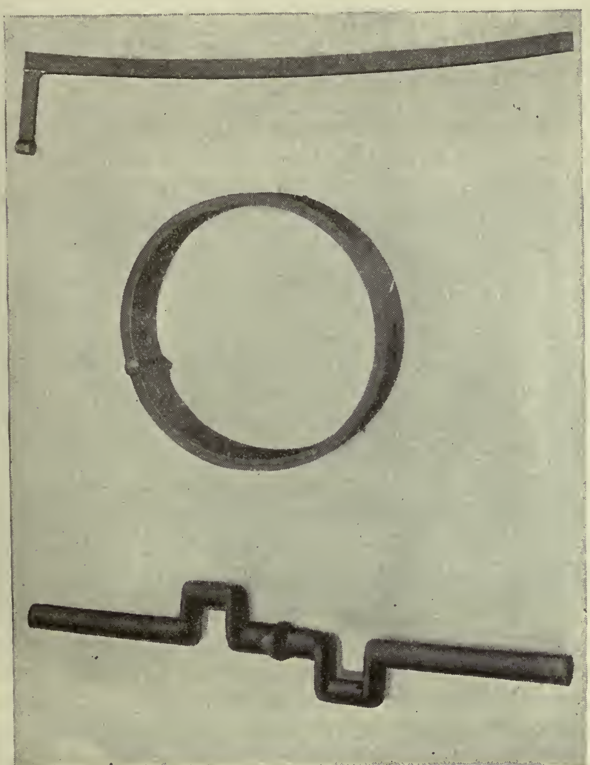
Power and Time for Butt Welding Brass.

Area. Sq. In	Power, kw.	Seconds.	Horsepower.
0.25	12	14	15.7
0.50	15	20	20.0
1.00	29.5	28	39.5
2.00	53	40	71,0
3.00	66	49	88.5

Power and Time for Butt Welding Copper.

Area. Sq. In	Power, kw.	Seconds.	Horsepower.
0.125	8.5	7	11.5
0.250	18	10	24.0
0.500	32	14	43.0
1.00	55.5	20	75.0
1.50	68	25	91.0

The character of resistance welding power loads depends largely upon the work that is being done. It is naturally very unsteady, and somewhat inductive.



Unfinished Forgings of Meat Saw Back, 3½-in. Ring and Two Single Throw Cranks Welded With Thomson Welder.

CHAPTER XV

ELECTRIC STEAM BOILERS.

Application.—Where conditions are such that electric energy may be obtained at low cost during off peak periods or otherwise, or where only a small quantity of steam is required for certain operations, electric steam boilers may often be used advantageously.

Industrial plants require steam for numerous purposes other than that of simply driving engines. Many machines, such as laundry apparatus and similar devices, may use steam heat to better advantage than the usual form of electric heat. Where this condition obtains, steam boilers may be heated electrically to effect the desired results.

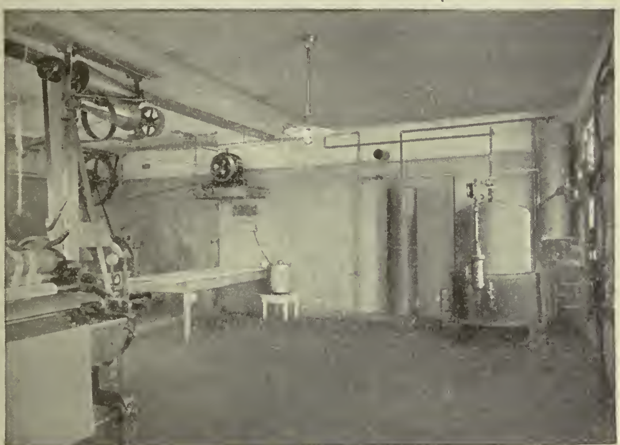
Although electric steam boilers have not yet been applied very generally in the industrial field it is probable that the superior advantages which they afford will tend to bring them into wider use.

Advantages.—The inherent features of electric steam boilers which commend them for industrial purposes are their efficiency of operation (often as high as 95 per cent), the reduction of labor cost, (no firemen needed), the safety of operation, (no danger of fire) and the convenience of location. As usual where electric heat supplants fuel heat the annoyance of fuel burners, the heated atmosphere and the dirt are done away with. The boilers may be installed in any convenient location and in places where other generators would be entirely impractical.

Steam Boiler Calculations.—In order to make intelligent recommendations for steam boiler installations it is necessary to know something of the fundamental principles of steam generation, the customary methods of rating the apparatus, and how to calculate the capacities required. The most important features to be considered together with some elementary defi-

nitions, tables, and practical examples are therefore set forth for the convenient reference of those less conversant with the subject.

Boiler Efficiencies.—The definition of steam boiler efficiency is the ratio of the heat absorbed by the boiler in producing steam to the total amount of heat available. As electric steam boilers are usually well lagged and equipped with immersion heaters it is apparent that practically all the energy applied is absorbed by



G. E. Steam Boiler in Laundry of Estes Park (Colo.) Hotel.

the boiler in producing steam. The efficiency of electric boilers, therefore, may be as high as 95 per cent. The efficiency of a fuel-fired boiler, on the other hand, may vary anywhere from 50 per cent, or even less, to 80 per cent, depending upon the method of firing, the kind of combustible consumed, and the numerous losses of heat, the chief of which is that due to the temperature of the chimney gases.

Boiler Horsepower.—The function of a boiler is that of producing steam by the evaporation of water and the term horsepower, having to do with the rating of boilers, should not be confused with the term horsepower relating to prime movers. Boiler horsepower is a measure of evaporation and not of power. It is equal

to an evaporation of 34.482 pounds of water per hour from and at 212° F. Since 970.4 B.t.u. (latent heat of evaporation) are required to evaporate a pound of water at atmospheric pressure after it has attained a temperature of 212° F., it is apparent that a boiler horsepower is equivalent to 34.482 × 970.4 or 33,461 B.t.u.

Factors of Evaporation.—In order to calculate the amount of water that a boiler of a certain horsepower rating will evaporate per hour when supplied with water at a certain temperature and operated at a certain pressure, it is necessary to divide by the corresponding factor of evaporation found in Table I.

TABLE I.

Factors of Evaporation.

(Calculated from Marks and Davis Tables.)

Feed Temp.	Gauge Steam Pressure					
Deg. F.	50	60	70	80	90	100
32	1.2143	1.2170	1.2194	1.2215	1.2233	1.2251
40	1.2060	1.2087	1.2111	1.2131	1.2150	1.2168
50	1.1957	1.1984	1.2008	1.2028	1.2047	1.2065
60	1.1854	1.1881	1.1905	1.1925	1.1944	1.1961
70	1.1751	1.1778	1.1802	1.1822	1.1841	1.1859
80	1.1548	1.1675	1.1699	1.1720	1.1738	1.1756
90	1.1545	1.1572	1.1596	1.1617	1.1636	1.1653
100	1.1443	1.1470	1.1493	1.1514	1.1533	1.1550

Assume a boiler of 5 h.p. rating supplied with feed water at 50° F. and operated at 60 pounds gauge pressure. The boiler will evaporate 5 × 34.482/1.1984 = 143.9 pounds of water per hour.

(The same boiler would, of course, evaporate 5 × 34.482 = 172.4 pounds of water per hour if supplied with feed water at 212° F. and operated at zero pounds pressure).

Calculating Boiler Capacity.—It is necessary to know three things in order to calculate the boiler capacity required for any purpose with any degree of accuracy—(1) the boiler feed water temperature, (2) the steam pressure desired, and (3) the number of pounds of water that is to be evaporated per hour. The process is as follows:

(1) Find the factor of evaporation from Table I corresponding to the temperature and pressure given.

(2) Multiply the pounds of water evaporated by the factor of evaporation and divide by 34.482. The result will be the required boiler capacity (neglecting losses in steam distribution).

In case the number of pounds and character of fuel consumed under a boiler are known, the approximate boiler capacity utilized, or the equivalent capacity required, may be determined as in the following example:

Assume boiler consumes 40 pounds of 14,000 B.t.u. coal per hour with an assumed efficiency of 60 per cent. Then $40 \times 14{,}000 \times .60 = 336{,}000$ B.t.u. input.

Since one b.h.p. = 33,461 B.t.u.,

Then 336,000/33,461 = 10 boiler horsepower capacity.

Electrically Heated Boilers.—Since a boiler horsepower is equivalent to 33,461 B.t.u. per hour (the heat required to evaporate 34.482 pounds of water from and at 212° F.), and since one kilowatt-hour is equivalent

G. E. Steam Boiler Applied to Shoe-Stitching Machine.

to 3412 B.t.u. per hour, it is apparent that the capacity required to operate a standard boiler at 100 per cent efficiency is equal to 33,461/3,412 = 9.8 kilowatts per boiler horsepower. On the basis of 95 per cent efficiency (which is a fair average for electrically heated boilers) the capacity required would be 9.8/.95 = 10.3.

Comparative costs of operating fuel and electric steam boilers under assumed efficiencies and using fuel and electricity at various costs and rates are shown in Table II.

TABLE II.

Hourly Operating Costs per B.H.P. in Cents.

60% Efficiency—Boiler Using 14,000 B.t.u. Coal. Cost of Fuel per Ton.			95% Efficiency—Boiler Using 3412 B.t.u. Electricity. Cost of Current per kw-hr.		
$2.50	$5.00	$10.00	1c	2c	3c
.5c	1.0c	2.0c	10.3c	20.6c	30.9c

Although the cost of steam produced with fuel is much less than that produced electrically according to Table II, the labor cost and the many disadvantages of fuel must also be taken into accounts in making intelligent comparisons.

Electrical Energy Required to Evaporate Water.—In order to determine the amount of energy required to evaporate a certain weight of water per hour supplied at certain temperatures and operated under certain pressures Table III will be found useful.

TABLE III.

Watts Capacity Required to Evaporate one Pound of Water per Hour Into Steam Assuming Certain Initial Feedwater Temperatures and Certain Final Pressures.

(Transformation 100% Efficiency.)

Lb. Gauge	Initial Feed Water Temperatures Degrees Fahr.							
Pressure.	40	50	60	70	80	90	100	110
0	334.8	331.9	328.9	326.0	323.1	320.2	317.2	314.3
10	337.7	334.7	331.8	328.9	326.0	323.0	320.0	317.2
20	339.6	336.6	333.7	330.8	327.9	324.9	322.0	319.1
30	341.0	338.1	335.1	332.2	329.3	326.3	323.4	320.5
40	342.1	339.2	336.2	333.3	330.4	327.5	324.5	321.6
50	343.0	340.1	337.2	334.2	331.3	328.4	325.4	322.5
60	343.8	340.9	337.9	335.0	332.1	329.2	326.2	323.3
70	344.5	341.5	338.6	335.7	332.7	329.8	326.9	324.0
80	345.0	342.1	339.2	336.3	333.3	330.4	327.5	324.5
90	345.6	342.6	339.7	336.8	333.9	330.9	328.0	325.1
100	346.0	343.1	340.2	337.3	334.3	331.4	328.5	325.5

Assume 100 pounds of water at 60 degrees F. feedwater temperature is to be evaporated under 70 pounds pressure and at an efficiency of 95 per cent. The capacity required would be: 100 (pounds) $\times$ 338.6 (from table III)/.95 (efficiency) = 35,642 watts or 35.642 kw.

Furthermore, since one boiler horsepower is equivalent to 10.3 kw. at 95 per cent efficiency, the

size boiler required for the operation would be:

$35.642/10.3 = 3.46$ boiler horsepower.

These figures may be checked by the method suggested under paragraph headed "Calculating Boiler Capacities."

Steam Boiler Apparatus.—The Simplex and General Electric companies manufacture electric steam boilers in various capacities. They are usually equipped with water and steam gauges, safety valves, and other standard boiler fittings. Simplex boilers

G. E. Electric Steam Boiler.

are of the horizontal type and are somewhat similar to so-called "fire tube boilers" in that the heating elements are inserted in longitudinal tubes passing through the shell. These tubes are welded in the boilers and the heating elements may be readily removed for inspection and repairs.

The General Electric boilers are of the vertical type and are usually heated by means of direct immersion heaters which are inserted into the shell radially and from the outside. They are mounted in rows around the circumference and near the bottom of the tank. The capacity of each unit is one kilowatt and obviously a large number are employed for heating the larger boilers. The sizes and capacities of General Electric steam boilers are set forth in Table IV.

TABLE IV.

General Electric Steam Boilers.

No.	Kw. Capacity.	Lbs. Evap. per hr. From and at 212° F.	Approx. Boiler Horse-power.	Gallons Capacity, Full.	Height Over all In Ins.	Floor Space In Feet.
10	30	101	2.9	85	59	3 x4
11	45	151	4.4	110	66	3 x4
12	60	201	5.8	145	74	3½x4½
13	85	285	8.3	180	79	3½x4½
14	100	335	9.7	250	85	4 x5
15	150	503	14.6	340	92	4½x5½
16	200	671	19.5	480	104	5 x6

To determine the amount of water which the different sized boilers will evaporate under various pressures and with various feedwater temperatures, divide the figures in column 3 by the corresponding factors of evaporation found in Table I.

The boilers are all thoroughly lagged with heat-insulating material. Although it might be considered unsafe to operate the present open shell and fire tube types of electric boilers at excessively high pressures, there seems to be no obvious reason why electric steam boilers might not be designed on principles similar to those of water tube boilers and operated at any desired pressures.

CHAPTER XVI

GENERAL APPLICATIONS OF ELECTRIC HEAT.

Diversity of Use.—Although it is impossible to enumerate in a single chapter the many uses to which electric heat has been successfully applied, a number of its possible applications in the industrial field are set forth. The descriptions are arranged in alphabetical order for convenient reference.

Automobile Heater.—A number of small low wattage heaters have been developed for placing in automobile hoods to keep the engines and radiators warm in cold weather. These heaters keep the water from freezing and make the engines start more easily.

Bacteriological Incubators.—Electric heat is particularly well adapted for bacteriological work. The

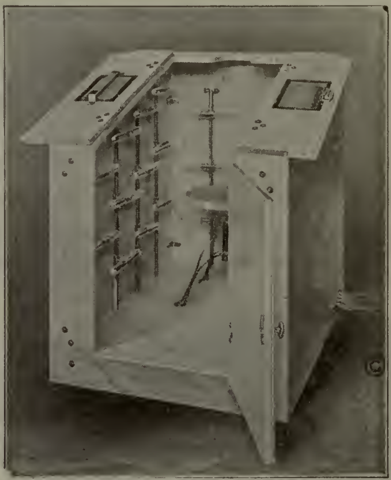
G. E. Bacteriological Incubator.

character of the heat afforded, the positive automatic temperature control apparatus available, and the absence of fire hazard make electrically heated devices of this nature very desirable. A number of bacterio-

logical ovens are in actual successful use and the desired temperatures are maintained to within a fraction of a degree.

Bath Cabinets.—Every advantage of the Turkish or steam bath room is afforded by the electric cabinet bath, and it is being substituted for them quite generally. The expense of maintaining hot air and steam rooms and the disagreeable features attending their use are thereby eliminated and the patients given better and more healthful treatments.

The cabinets are usually constructed of wood, steel, or marble and are designed for patient's use



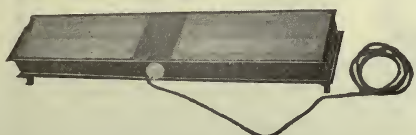
Electric Bath Cabinet.

in either a sitting or reclining posture. The interiors are lined with reflecting surfaces. Rows of electric lights (usually carbon filament) are mounted close to these reflecting surfaces and the patient receives the beneficial effect of the actinic light rays as well as of the heat produced by the lights surrounding him. The wood and steel cabinets are generally lined with mirrors, whereas marble acts as the reflecting surface where it is used. The patient's head is always allowed to protrude from the cabinet and he is never forced to breathe the hot air contaminated by the toxic

emanations of his person, which is unavoidable in the hot air and steam rooms.

The marble cabinet shown in the illustration is made by James B. Clow & Sons. It is lined with 56 sixty-watt carbon lights and has a total capacity of 3360 watts when all the six control switches are closed. The range of temperature is from 80 deg. to 180 deg. F. From 3 to 10 minutes is required to bring out a sweat and the average duration of the bath is from 12 to 20 minutes, depending upon the initial heating, the outside temperature, and the physical condition of the patient.

Beer Vat Dryer.—For drying out vats in a brewery during the varnishing season, the General Electric beer vat dryer is convenient and satisfactory. It is 4 feet long, 8½ inches wide, 4 inches high and is fitted

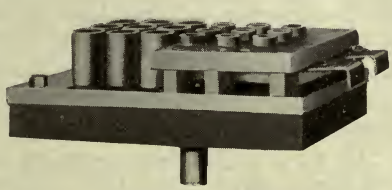


G. E. Beer Vat Dryer.

with six 500-watt resistance tubes mounted on center and end castings. The ends and sides are of sheet metal, and the top and bottom of galvanized wire mesh. It is claimed by the manufacturers that one of these devices will dry out a 50-barrel vat in about 10 hours. Two heaters are recommended for a 150-barrel vat, and three for a 350-barrel vat.

Branding Irons.—A large number of special electrically heated branding irons are in use. They are ideal for branding wood, leather, meats, etc.

Button Die Heater.—Electrically heated dies have been used for some time in the manufacture of cellu-

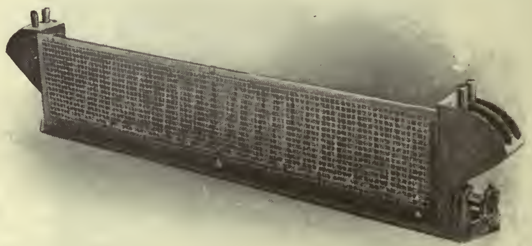


C. H. Heater Applied to Celluloid Button Die.

loid buttons. These devices are made in capacities of from 60 to 150 watts, and are usually controlled by rheostats mounted on the bed plates. A number of dies may be mounted on one head.

Can Capping Machine Heater.—An application of electric soldering iron units of 250 watt capacity to can capping machines has been designed by the General Electric Company. Apparatus operated in this manner has been found much more satisfactory than gas heated equipment.

Candy Batch Warmer. — The electric batch warmer is portable and has a swing adjustment so that the heat can be thrown in different directions as desired. It serves the same purpose as the open gas



C. H. Batch Warmer.

warmer, but has certain obvious advantages over fuel apparatus.

The Cutler-Hammer batch warmer is made in two standard sizes, as follows:

Length in Inches.	Watts.	No. Heats.
24	2500	3
48	5000	6

Celluloid Embossers.—A method of attaching 25 watt and 38 watt soldering iron units to the embossing heads on the lower part of celluloid embossing presses has been developed by the General Electric Company. The electrically heated dies are ideal; a maximum temperature of 140° F. is maintained; and all danger from working with inflammable material is obviated.

Chocolate Warmers.—For maintaining chocolate at proper temperature for dipping, the electrically heated warmers have proved their superiority on account of the accuracy of adjustment possible and the cleanliness and convenience afforded. They consist of two pans; an inner one holding the chocolate and an outer one fitted with a surface heating element.

Chocolate warmers in the following sizes and capacities may be obtained for flush mounting on dipping tables:

C. H. Chocolate Dipping Table With Warmer and Side Pans.

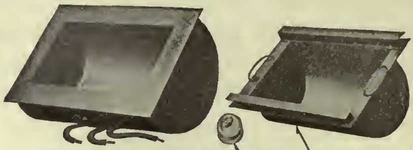
Rectangular Chocolate Warmers (Cutler-Hammer).

Quarts Capacity, 2/3 Full.	Inside Dimensions in Ins. Length.	Width.	Depth.	—Watts— High.	Medium.	Low.
4	12 3/16	6 3/16	5	180	90	45
6	14 1/16	7 5/16	5¾	220	110	55
10	14½	10	7	310	155	77
12	20	12	5½	375	188	94
Rectangular Type (Westinghouse).						
4	12	6½	5	220	110	55

Round Type Chocolate Warmer (Cutler-Hammer).

Quarts. Capacity. 2/3 Full.	Inside Dimensions, Ins. Diameter.	Depth.	—Watts— High.	Medium.	Low.
4	9	6¾	160	80	40

Electrically heated side pans are furnished with the Cutler-Hammer rectangular chocolate warmers instead of marble slabs. Two of them may be mounted on opposite sides of the warmer. They are made in the following standard sizes:



Westinghouse Chocolate Warmer.

Heated Side Pans.

Dimensions in Inches.	Watts.
12″ x 15″	25
12″ x 17″	29
12″ x 22½″	38

Clothes Dryers.—Where fuel cost is high or where operating cost is relatively unimportant in comparison with convenience, electrically heated clothes dryers are desirable. It is obvious that the drying of clothes in the laundry saves time and eliminates the many disadvantages of hanging out the washing on the old-fashioned clothes line.

The Chicago electric dryer is made of heavy gauge galvanized sheet metal with single casing, double casing insulated with asbestos, or double casing insulated with an intervening air space. The panels of the racks are of similar material. The rear panels are provided with extension plates, so that when the racks are pulled out, the heat will not escape from the machine. The brackets are of cast iron, and the hanging bars are of galvanized pipe. The sheave wheels are run on ball bearings. The base of the cabinet below the racks is provided with galvanized wire screen for the protection of clothes that might fall from the racks.

The electrically heated dryers are made in four standard sizes for use on 110 or 220 volt circuits.

Dryer Number.	Outside Dimensions. Height.	Length.	Width.	No. Racks.	Lineal Ft. Hanging Capacity	Kw. Capacity.
E 29	7′	7′	2′ 1″	2	78	3
E 39	7′	7′	2′ 10″	3	117	4.5
E 49	7′	7′	3′ 7″	4	156	6
E 59	7′	7′	4′ 4″	5	195	7.5

Corn Popping Machines.—An electric corn popper of 1500 watts heater capacity and operated with a one-sixth horsepower motor is now available. It is similar to those seen in public places, and has a capacity of about 60 bags of popcorn per hour.

Corset Irons.—The Simplex corset iron is made in an 8½ pound, 500 watt size. It may be obtained with either a hand or an automatic regulator or a combination of both.

Drying Ovens.—Specially constructed ovens are used for drying lumber, for removing moisture in photogravure work, for drying leather boxes and traveling bag parts that have been glued, and for removing the moisture from bottles and cans before filling with powders.

Embossing Press Heaters.—Any gas or steam heated embossing head may be easily fitted with electric heaters and higher operating efficiencies insured. They may be heated quickly (usually from ten to fifteen minutes), and afford a sensitive and uniform temperature over the entire surface. Simplex embossing press heaters have been made in a great variety of sizes and capacities. They are usually made to order on account of the great variety of press heads in use. The heaters are flat discs about one inch thick. They are bolted to the press head and the embossing dies placed over them. They may be made in two or more sections, so that portions only of the head may be heated, if desired.

Cutler-Hammer press heads and press blocks are also manufactured in a variety of sizes and capacities for industrial use.

The following information is usually required for making up a design of press heater:

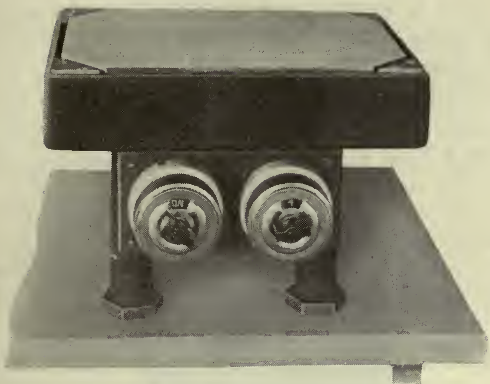
(1) Nature of work to be done.
(2) Speed of operation.
(3) Temperature required.
(4) Pressure to be applied.
(5) Dimensions of dies and manner applied.
(6) Sketch showing dimensions of press head.

Sheridan No. 8D Press Equipped With 46 in. x 33 in. Press Head.

Engraver's Stoves.—Three-heat stoves of 600 watts capacity are being used successfully for heating engraved plates during the inking process.

Envelope Gum Dryer.—With a 500 watt heating unit fitted in the blower cabinet, the capacity of a machine will be increased about 100 per cent.

Fan Drying Equipment.—A small dryer of 1000 watts capacity, which is attachable to a standard fan motor, has been developed by the General Electric Company. It has a wide field for application in pho-



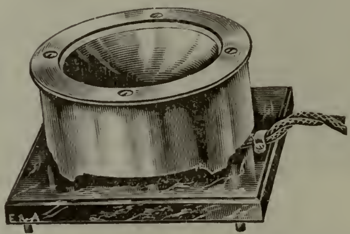
C. H. Engraver's Stove.

tographic studios for drying prints and negatives. The heating coils are mounted vertically in an aluminum frame and covered with a screen guard.

Motion Picture Film Dryer.

Film Dryers.—A large motion picture studio has developed a film drying oven, consisting of an outside casing, within which a large ribbed cylindrical reel,

similar to a ferryboat paddle wheel, is mounted. The oven is heated with four 3000 watt G. E. beer vat dryers mounted around the sides. The film is wound on the outside of the reel. The drying process completes work in 30 minutes that formerly required 10 hours' time, and much better results are obtained.



E. & A. Type FW Laboratory Flask Heater.

Flask Heaters.—A flask heater for laboratory use is very convenient. It is made of copper with a concentric ring top. The small size is 8½x4 inches deep, and consumes 500 watts at maximum heat.

Gilding Wheel Heaters.—These devices are used for bookbinding, and are convenient on account of the absence of soot and dust and the concentrated heat afforded. They are fitted with heaters which revolve on roller bearings. Ordinary dies may be used with these heaters by turning a recess on one side and drilling holes for the clamping studs. Simplex gilding wheel heaters are made in the following sizes and capacities:

77 watt heater,	3 19/32″ diameter,	21″ long.
85 watt heater,	4″ diameter,	21″ long.

A rheostat may be supplied with the larger size for finer temperature adjustment.

Glove Stretchers and Laying-off Boards.—The electrically heated glove stretchers and laying-off boards manufactured by the C. L. McBride Manufacturing Company are ideal for the dry cleaner and glove manufacturer. The stretchers are superior to the ordinary steam heated devices. Steam laying-off boards are not flexible; will not give to allow the gloves to be

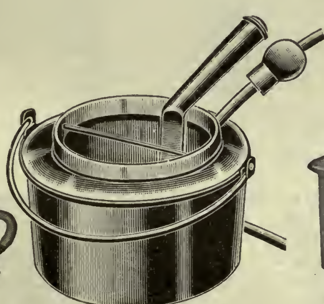
fitted, and consequently require more time to adjust the glove fingers. The heat also varies with the pressure, and the quality of the work is not uniform. These disadvantages are overcome in the electric glove stretcher. The temperature is regulated by a thermostat. It is mounted on a revolving base. The quality of the work is better, and may be done more rapidly and with less skilled labor than where steam is used. Only a relatively few forms are required, because each stretcher will make four full sizes of gloves from one form.

The electrically heated laying-off boards are made for finishing dry cleaned gloves, and may be used in a kid glove factory although they are too light for heavy gloves. They are much cleaner and safer and will turn out more and better work than steam boards.

Glue Pots.—Electrically heated glue pots eliminate soot, smoke, and flame; do away with steam and gas pipes; are readily moved from place to place, and insure even temperature regulation. They are manufactured both with and without water jackets.

The relative sizes and capacities of glue pots made by three prominent manufacturers are as follows:

Westinghouse Cast Iron Glue Pot.

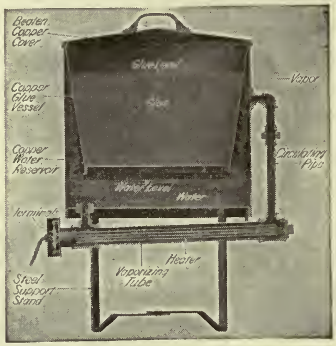


Simplex No. 408 Glue Pot.

General Electric Glue Pot.

Make.	Pot Capacity.	Small. Low.	Small. High.	Large. Low.	Large. High.		
Gen. Electric...	½ pt. to 8 qt.		20		250	jacketless	1-heat
Gen. Electric...	1 pt. to 4 qt.	85	340	275	1100	jacketed	3-heat
Westinghouse..	1 pt. to 4 qt.	55	200	200	660	jacketed	3-heat
Simplex	1 pt. to 2 qt.	110	440	220	880	jacketless	3-heat
Simplex	1 pt. to 20 qt.	85	330	625	2500	jacketed	3-heat
American	2 pt. to 4 qt.	125	500	250	1000	jacketed	3-heat

Glue Cookers.—Quantities of glue may be heated in large pots and transferred to small pots for use in various parts of an establishment. The cookers are usually heavily insulated against heat losses.



Section of a Westinghouse Glue Cooker.

Tabular specifications of standard Westinghouse glue cookers are as follows:

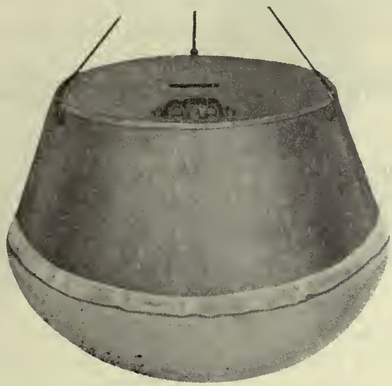
Gallons Capacity.	Watts Input. Starting.	Running.	No. of Heats.
3	1800	450	2
5	2200	550	2
10	2700	675	2
15	6000	750	5
20	6600	825	5
25	7200	900	5

The following data refer to standard General Electric glue cookers:

Gallons Capacity.	Watts Input. Starting.	Running.	Av. Hr. Time to attain 165° F.	Floor Space in feet.
20	10,500	450	1	3¼x3¼
35	14,000	500	1¼	3½x3½
50	16,500	600	1½	3¾x3¾
80	20,000	700	1¾	4 x4
140	26,500	850	2	4½x4½
220	32,000	1,050	2½	5 x5

Gold Leaf Stamp Heaters.—These devices may be used in place of gas for stamping gold leaf on combs, pipes, neckwear, etc. A Simplex die heater consuming 80 watts has been designed to fit a standard pencil stamping machine for imprinting gold leaf letters.

Hatters' Flanging Bags.—Electrically heated flanging bags are superior in every way to bags heated over steam bake ovens. The heat is constantly generated within the bag; the thermal efficiency is greater; the temperature is more uniform; and no time is lost



C. H. Flanging Bag.

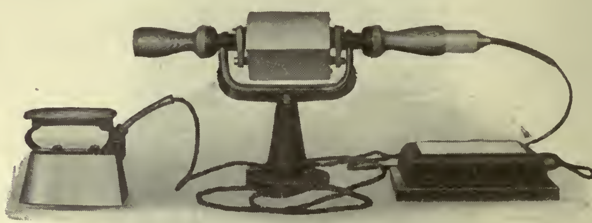
in reheating. Hats may be flanged in less time and with better and more uniform results. The Cutler-Hammer flanging bags consume 440 watts, and are furnished with a metal pan fitted with lifting ears. The sand, lifting tackle and canton flannel covering are provided by the user.

Hatters' Hand Flats.—Four faces of the straw hatters' hand flats are working surfaces. Three standard styles are made by the Cutler-Hammer Company. The hand flat is mounted on a support, and may be used in any desired position. Cleanliness is essential in the manufacture of straw hats, and the clean, uniform heat supplied by the electric hand flat makes for increased speed and perfection of product. The energy required for these devices varies from 550 to 700 watts, depending upon the style of hand flat used.

Hatters' Hand Shell.—The Cutler-Hammer hatters' hand shells conform in shape to the old-fashioned shells. The body of the shell is a single casting, and can be dipped in water for cooling the faces of the iron. These irons are made in the following standard weights and capacities:

Weight in Pounds.	Watts.
9	300 or 350
10½	300 or 350
12	350 or 500
15	350 or 500

Simplex hatters' irons are made in 9 and 15 pound sizes, and with 450 watts capacity each. They may be provided with plain or automatic regulators.



C. H. Hand Shell, Hand Flat and Velouring Stove.

Hatters' Velouring Stove.—The Cutler-Hammer velouring stove is encased in a heavy cast iron frame with tight joints to prevent particles of felt from lodging in the crevices. They are made in the following standard sizes for either single or two-heats:

Size of Top, in Inches.	Single-Heat.	Watts Capacity Two-Heat.
4½x6	315	315-475
5¼x7	450	450-675

Doran Machine Iron Nos. 1 and 2.

Hatters' Machine Irons.—Irons for use on hatters' machines are more satisfactory, more economical, and result in better work and greater output than other such appliances. Gas heated machine irons, equipped

with gas and air-blast tubes, soon develop loose connections, create dangerous hot spots, and do not maintain a uniform heat.

Tweedy Right Hand Curling Machine Iron.

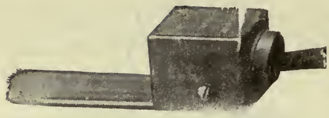
Cutler-Hammer irons are made for the following hat blocking and curling machines:

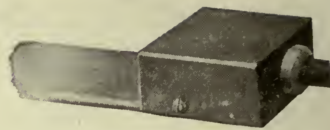
	Watts.
Doran Machine Iron No. 1	300
Doran Machine Iron No. 2	300
Doran Machine Iron No. 3	275
Newark Machine Iron	400
Tweedy Right Hand Curling Iron	750
Tweedy Left Hand Curling Iron	750

Hot Air Blower.—A 25 kilowatt General Electric hot air blower fitted with 152 ribbon wound flat heating units and a blower fan has been found useful for drying transformers and other simliar operations. The volume and temperature of the air supplied naturally depends upon the size and speed of the fan.

Industrial Heating Units.—In order to avoid designing and manufacturing special heating units for each industrial application that is presented, the General Electric Company has standardized on three types of units, one or more of which are adaptable to the usual conditions that are met. These units are known as cartridge, flat leaf, and tubular type units.

Cartridge units are made in various capacities up to 750 watts, and in sizes up to 1¼ inch diameter and 8 inch length. These units operate at a dull red heat. They are usually fitted into drilled holes in castings and bolted to the body to be heated. They consist of


Westinghouse Narrow Type Industrial Heater.


Westinghouse Wide Type Industrial Heater.

resistance ribbons wound edgewise, cemented and sealed inside of metallic tubing.

Flat leaf units are used for heating flat surfaces. They are made in capacities of 300 watts or less and with dimensions of 6 inches by 2 inches by 3/8 inch. They consist of resistance ribbons wound on mica sheets and clamped between iron protecting plates. Any desired number of these units may be bolted to the surface of any smooth, flat surface to be heated.

Tubular type units are used for air heating and are made for low temperature work. The standard

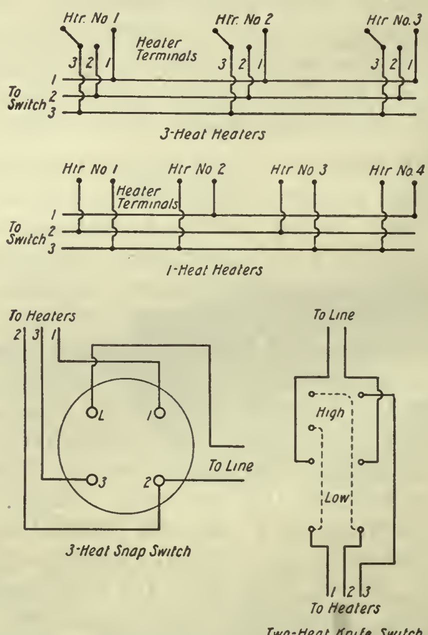


Diagram for Connecting Two Single Heat Heaters or Multiples Thereof for Three Heat Control.

size is 2 in. in diameter and 22 in. long, and dissipates about 350 watts. It consists of resistance wire wound on an asbestos tube and coated with a stiffening of insulating compound.

The Westinghouse Company has recently developed a very complete line of "steelclad" heating units for industrial purposes. They consist of flat ribbon resistors assembled on mica sheets covered with steel casings, and provided with suitable terminals. They are made in the form of bayonets with single or three heat control, in lengths varying from 10 in. to 50 in. The narrow type is ⅛ in. thick and 1⅛ in. wide, and the wide type 3/16 in. thick and 2¼ in. wide. The wattage of these units may be calculated from the following table:

Class.	Maximum Watts per Inch of Length. Wide Type.	Narrow Type.
A (Ovens and drying rooms)........	15	7.5
B (Ordinary Air Heating)	30	15
C (Pressheads, hot plates, etc........	50	25

Ironing Machines.—Laundry machines of all kinds may be equipped with electric heaters. They insure a clean, sanitary, cool laundry, and result in producing more and better work. An example of an application of electric heat in the laundry is that of the American Iron Machine Company's "Simplex Ironer," which is made in the following sizes and capacities:

Simplex Ironers.

Length of roll in inches.	24	26	32	37	42	46	48	56
Diam. of roll in inches..	6	7	7	7	7	7	8.5	8.5
Ironing shoe face in inches	5	8	8	8	8	8	9	9
Ironing shoe contact, ins..	2.5	5	5	5	5	5	6	6
Ironing speed ft. per min.	6.5	7	7	7	7	7	8.5	8.5
Kw. capacity—high......	1.85	2	2.5	3	4	4.8	5	6
Kw. capacity—medium...	1.25	1.3	1.7	2	2.7	3.2	3.4	4
Kw. capacity—low.......	.60	.75	.85	1	1.3	1.6	1.7	2
Size of motor in hp......	1-10	1-8	1-8	1-8	1-6	1-6	1-4	1-4

Laboratory Hot Plates.—The uniform, dependable and safe heat obtainable from electric hot plates and stoves make them most desirable.

Simplex 4½ in. by 24 in. Laboratory Hot Plate.

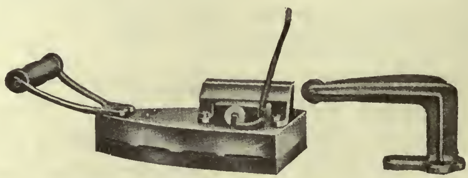
Rectangular Simplex hot plates of the following dimensions and capacities are available for securing various temperatures:

6″ x 6″	500 watt	three-heat
6″ x 12″	750 watt	three-heat
2¾″ x 24″	500 watt	three-heat
4½″ x 24″	600 watt	three-heat
3″ x 6″	200 watt	three-heat
6″ x 6″	350 watt	three-heat

Small, round Simplex discs in sets of six mounted on slate bases are convenient for milk testing and other laboratory operations.

6- 3½″ discs total 600 watts single-heat.
6- 4½″ discs total 1500 watts single or three-heat.

Laundry and Tailors' Irons.—The conditions under which these irons are used are vastly different than those in the home. They are usually subject to rough.



Simplex No. 1540 Drag Iron.

careless handling, and severe long hour use. They must be heavily and durably constructed to meet ordinary requirements.

A large variety of irons are available for industrial use. Pointed and round nose, smoothing and finishing irons are manufactured in many sizes. Those made for laundry work usually vary in weight from four to twelve pounds and consume from 275 to 750 watts. Drag irons are made in weights of from 30 to 50 pounds and wattages of from 1400 to 1600 watts. Puff irons in egg and half egg shapes are made in capacities of from 150 to 400 watts.

Tailors' irons usually vary from 12 to 25 pounds in weight and from 600 to 900 watts in capacity. They are made with diamond, oval, and special broad noses. Simplex irons of various sizes and shapes are made for use in pressing machines.

Westinghouse, American, Cutler-Hammer, General Electric and Simplex laundry and tailors' irons are manufactured in a variety of types, shapes and sizes.

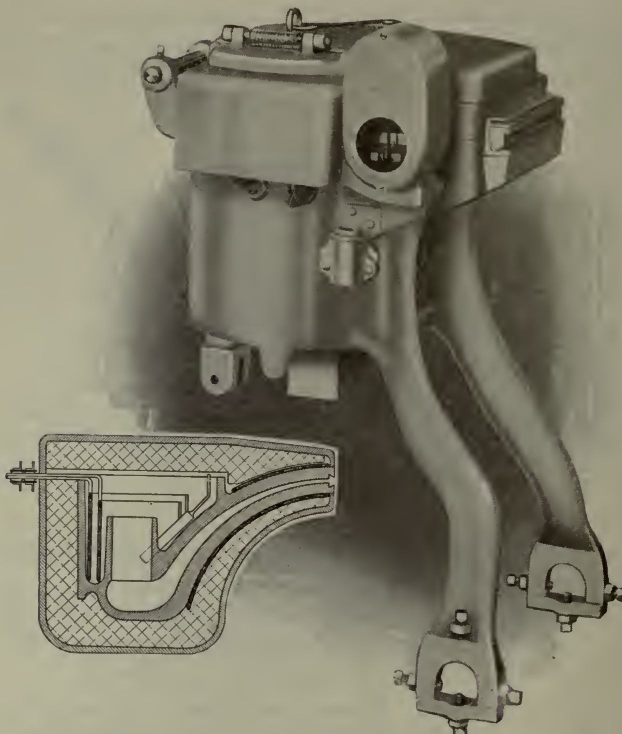
C. H. Tailor's Iron.

Leather Creasing Tool.—A recently developed device for branding designs, ruling parallel lines, and edge finishing leather articles has been found very useful. The tool is designed on the principle of a soldering iron and differs only in the tip and handle.

Linotype and Monotype Pots. — Among the numerous advantages gained by the application of electric heat to type metal pots are rapid heating, perfect temperature regulation, absence of gas fumes, smoke and soot, elimination of excessive room temperature, ideal working conditions, no burning out of the tin of the metal mixture, and production of solid, sharp slugs.

The Cutler-Hammer pots are equipped with immersion heaters, heavy thermal insulation, and automatic temperature control. The latter consists of a dynamic thermometer and a magnetic switch panel. Expansion or contraction of mercury in the thermometer actuates a relay which in turn operates the magnetic switch, cutting the current in the heating elements on or off.

It maintains a temperature of approximately 550° F. in the type metal. Initial heating requires



C. H. Linotype Pot.

1600 watts, for about 50 minutes after which 550 watts is sufficient to maintain the temperature when 100 slugs are being cast per hour.

G. E. Monotype Pot.

The General Electric pots are usually equipped with standard cartridge units. Regulation of the heat is obtained by means of a hand operated rheostat. For heating a linotype pot holding 40 pounds of metal a

maximum capacity of 2250 watts is provided. To maintain working temperature using 8 pounds of metal per hour 750 watts is required. For heating the same weight of metal in a monotype pot 2900 watts is provided, and for maintaining the proper temperature, using 16 pounds of metal per hour, 2400 watts is required.

Liquid Heating Tanks.—Manufacturing processes that require the use of hot liquids for dipping purposes may often utilize electrically heated tanks to advantage, especially where the solution is of an inflammable or explosive nature. The vessels are usually well lagged and fitted with covers.

Tanks of the following dimensions and capacities are made for heating liquids by the General Electric Company:

Capacity in Gallons.	Total Kilowatts.	Outside Dimensions. Diameter.	Height.	Average Hours Required for Heating Oils to 212° F.
40	16.5	27″	25″	1.3
60	22.5	31″	29″	1.4
85	30	35″	31″	1.5
125	39	39″	35″	1.7
200	52.5	46″	40″	2
300	58.5	54″	45″	2.7
500	67.5	62″	55.5″	3.9
750	75	70″	62.5″	5.3
1000	79.5	76″	68.5″	6.7

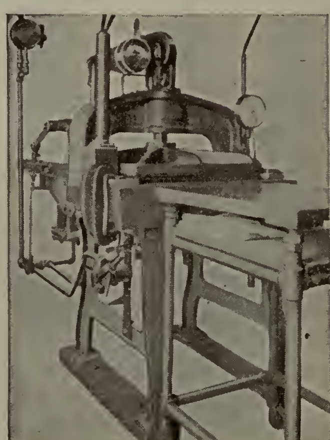
Matrix Dryers.—The most important factors to be considered in matrix drying are quality of the mat, cost of drying and speed of drying. The temperature usually required for this work is from 350° to 400° F. The common methods of drying are accomplished by the use of either gas or steam heat. In addition to the many obvious disadvantages of gas heated apparatus, it does not provide the uniform temperature that is so desirable for this class of work. Steam heated dryers, on the other hand, supply a uniform heat, but unless excessively high pressures are available the operating temperatures are too low for quick work.

Electrically heated matrix dryers have overcome all the undesirable features of other apparatus. The heat is clean, safe, dependable, and automatically regulated to provide the desired operating temperatures,

C. H. Matrix Machine Heater.

and it does away with the maintenance of troublesome and costly equipment.

Cutler-Hammer matrix dryers are manufactured complete, ready to slip into the bed of the machine.



G. E. Matrix Drying Press.

The temperature is regulated by the pressure of saturated steam generated in a tube cast into the heater and attached to a contactor pressure gauge, which in

turn actuates a magnetic switch, cutting the current on and off. The dryer is also fitted with pilot lamps to indicate when energy is being consumed.

General Electric matrix dryers are also automatically controlled. The standard size is rated at 28 kilowatts, and is applied intermittently by the automatic regulator. It is claimed by the manufacturers that these dryers will consume about one kilowatt per hour per mat.

Meat Brander.—This device is used for inspection stamps and is legible at end of curing process. A ham branding die made by the General Electric Company consists of a 21 pound block of cast iron heated with two 600 watt cartridge units. The branding die is of cast brass inserted in the top of the body casting. After initial heating, low heat is maintained. Each ham is branded by placing it on top of the heated die for from 3 to 4 seconds.

Metal Melting Tanks.—For bringing tin, lead, solder, babbitt metal and various alloys to the melting point, electrically heated tanks can often be used to advantage, especially where it is desirable to secure accurate temperature adjustment. These tanks should be heavily constructed and provided with efficient thermal insulation.

Tanks of the following sizes and capacities are manufactured by the General Electric Company:

Capacity 80% Full. Lbs. Lead.	Lbs. Tin.	Inside of Tank (inches). Diam.	Length.	Width.	Depth.	Watts Capacity.
30	19	4¾″	...	...	5½″	2,100
50	30	5½″	...	...	6½″	2,400
75	45	6½″	...	...	6⅞″	3,000
100	60	7″	...	...	7⅞″	3,900
200	125	9″	...	...	9½″	4.550
300	190	10″	...	...	11⅝″	6,500
400	250	11″	...	...	12¾″	8,450
560	360	...	15″	13″	9″	13,000
800	520	...	15″	13″	13″	15,600
1080	690	...	20″	13″	13″	17,500
1230	860	...	20″	16″	13″	22,100
1640	1050	...	20″	16″	16″	22,800
2060	1275	...	25″	16″	16″	26,000
2330	1600	...	30″	16″	16″	28,600
2960	1900	...	30″	19″	16″	30,000

It is claimed that a 3000 watt pot will melt approximately 52 pounds of alloy consisting of 18 parts anti-

mony, 20 parts tin, and 100 parts lead in one hour. Medium heat will perform the same operation in 3 hours.

Cutler-Hammer type metal crucibles are made with external or immersion heaters in sizes of from 50 pounds to 500 pounds capacity.

G. E. Metal Melting Tank.

Number Brander.—This recently developed device consists of an electrically heated circular plate. on the outside of which is mounted a small wheel bearin ⅜ in. figures reading from 0 to 9.

G. E. Oil Tempering Bath.

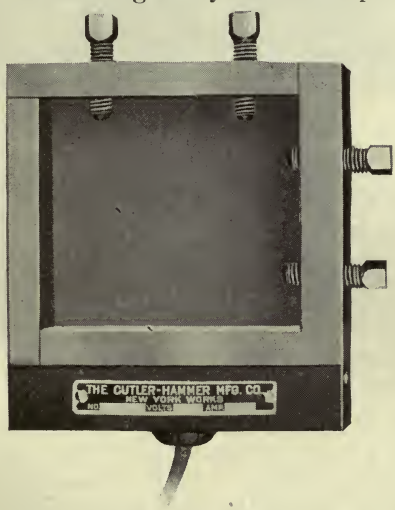
Oil Tempering Baths.—Where a large amount of tool tempering is done the electric oil bath is indispensable. Uniform temperature control is attained, and fire hazard, uncertainty, and harmful oxidation of the metals is eliminated in this process. The work may be done successfully with unskilled labor because the temper is drawn by the submersion process.

General Electric oil tempering baths furnished with or without cooling coils and controlling panels are made in the following standard sizes and capacities:

Oil Capacity Gallons.	Dimensions in Inches. Length.	Width.	Depth.	Maximum Kilowatts.
9	22	12	8	6
11	18	12	12	7.2
37	30	16	18	20

The drawing temperature of different grades of steel varies from 300° to 320° F. The 20 kilowatt size bath is said to have drawn the temper of 363 pounds of steel ball bearings in 1 hour and 45 minutes with a total energy consumption of 9.5 kilowatt hours.

These baths are being used successfully for melting rosin compounds required in the manufacture of shrapnel shells. They may be used equally as well for heating and melting many other compounds.



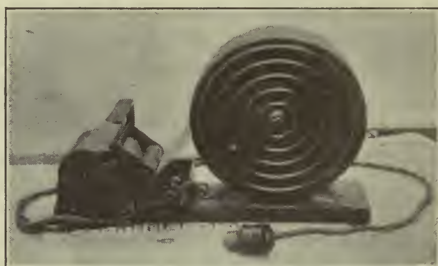
C. H. Pallette Heater.

Pallette Die Heaters.—In book binding establishments these devices have a number of advantages because of the concentrated heat, freedom from dust and soot, and better working conditions brought about.

The Simplex standard machine die heater is of 140 watts capacity, and fitted with rheostat and flexible cord. It is provided with a triangular piece of metal

across the back for fastening in the head of the machine. The rectangular pocket for the dies is 1½ in. x 2½ in. x ⅝ in. deep. The hand die heater is of 135 watts capacity. The groove for the die is ¾ in. x 5 in. x ½ in. deep. The length of the device including the handle is 9½ in.

Paper Seal Moistener.—Electric heat has been found convenient for heating water in the small paper seal moisteners used in sealing packages and cartons.



Paper Seal Moistener.

A small 30 watt heating unit immersed in a container 4 in. x 6 in. x 2 in. deep, will raise the temperature a sufficient amount.

Paper Warmer.—In order to do away with the sticking effect produced by static electricity General Electric tubular heaters have been placed under the paper of large printing presses and satisfactory results obtained.

Peanut Roasters.—Wm. B. Berry & Company has developed a line of electrically heated and operated peanut roasters. They are built in standard sizes of 16, 24, and 32 quart capacities, and in a number of designs. The latter is equipped with 1.2 kw. in heating units and will roast about one bushel of peanuts per hour. The manufacturers claim the machines have been used successfully for roasting coffee as well as peanuts.

Perforator for Drawings.—A recently developed heating device which makes minute perforations may be run over a drawing and the pattern used for a stencil.

Photographic Drying Oven.—An unlagged galvanized iron oven 5 ft. long, 30 in. wide, and 30 in. high, fitted with two 500 watt General Electric tubular type heaters mounted 2 in. from the floor is said to dry photographic prints in from 30 to 45 minutes, whereas from 3 to 4 hours was formerly required for drying them on blotting paper in the open air. Ventilation is provided by a 6 in. hole in the bottom and a small damper in the top. The prints are placed on blotting paper on three wire mesh shelves.

Another installation, consisting of a revolving galvanized sheet iron drum 3 ft. in diameter and 2 ft. wide, heated by means of a 2000 watt three-heat American radiator inside the drum, and operated by means of a 1/6th horsepower motor, gave very quick results. A cloth belt passing around the drum and over rollers mounted on the framework permitted the wet prints to be inserted between the surface of the drum and the cloth belt. The warm surface of the drum and the dry cloth rapidly remove the moisture.

Pipe Thawing Outfits.—Portable outfits have proven serviceable for thawing frozen pipes. The high tension leads are connected to the main line feeders and the low tension leads are attached to opposite ends of the frozen pipe section. In residences one lead is usually attached to the faucet and the other to a street hydrant. Connections may be made to two hydrants when street mains are frozen, or excavations may be made for attaching leads direct to the pipes.

Pitch Kettles.—Portable devices for heating pitch, varnishes, oils, etc., have a wide range of application They are usually provided with three-heat control switches. The maximum heat is used for heating up the substance, medium heat for stirring, and low heat for maintaining a constant temperature.

Simplex pitch kettles have the following dimensions and capacities:

12″ x 2½″ deep	4 quart	1300 watts	maximum.
15″ x 2½″ deep	7 quart	1600 watts	maximum.
19″ x 9 ″ deep	40 quart	3000 watts	maximum.
30″ x 14⅜″ deep	120 quart	7000 watts	maximum.

Pleating Machine Heaters.—An installation for pleating dress goods, made by the General Electric Company, consisted of a 600 watt heating unit fastened to the frame so as to project inside one of two 7-inch by 3-inch corrugated rollers, and a temperature of about 450° F. was attained. The electric heater was substituted for a gas burner, which was more or less dirty, dangerous, and uncomfortable to work over.

Pouring Pots.—Where it is desired to keep wax and pitch compounds at the proper consistency for pouring, General Electric portable pots, made in forms similar to its jacketless glue pots, are useful.

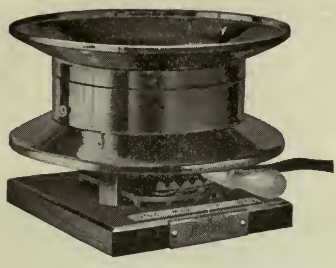
Printing Ink Heater.—In order to keep printing ink warm and fluid in cold weather, a small heating unit placed beneath the ink pad has produced good results.

Rectifier Tube Boiler.—For lengthening the life of rectifier tubes the General Electric Company has developed a means of boiling the tubes in water for removing the carbon deposits on the inside of the glass. A copper tank 29½ in. long, 16½ in deep, and 13 in. wide, lagged with asbestos paper, fitted with a tight cover and heated with nine 1175 watt cartridge units constitutes the equipment.

Roofing Material Vulcanizer.—This application of electric heat as a substitute for gas heat reduces the unit time of joining rolls of rubber roofing paper considerably. The heating units consist of mica insulated resistance ribbon clamped between iron plates (2 in. x 6 in. x 3/16 in. thick). These 350 watt units are attached to the under side of a 9 in. x 60 in. x ¾ in. thick iron vulcanizing plate, and a temperature of about 650° F. maintained. Electric operation eliminates gas fumes and fire hazard, and is far more convenient.

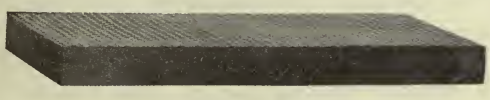
Sealing Wax Pots.—For applying large quantities of sealing wax, an electrically heated pot is more convenient than ordinary stick wax. Special Simplex devices made of spun copper and having the following capacities are in use:

½ pint	175 watt maximum	4-heat.
1½ pint	300 watt maximum	4-heat.



Simplex Sealing Wax Pot.

Shelf Heaters.—Cutler-Hammer electrically heated shelves form a means of heating ovens already built or in use. The shelves form separate units, which may be mounted in any oven of similar dimensions. They are suitable for use in incubators, lacquering



C. H. Self Heater.

ovens, plate warmers, evaporating and drying closets and laboratory cabinets. The shelves are of perforated sheet metal, mounted on iron frame work, with the heating units inside.

The standard sizes and capacities of these heaters are as follows:

Size in Inches			Maximum	Number of
Length.	Width.	Thickness.	Watts.	Heats.
12	6	1½	200	1
16	8	1½	350	1
20	10	1½	550	1
24	12	1½	750	3
24	16	1½	1,000	3
30	20	1½	1,500	3

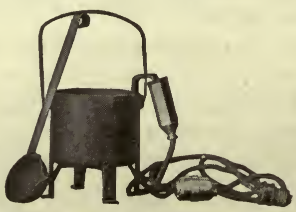
Shoe Relaster.—The Fern Company of Baltimore has placed an 80 watt relasting iron on the market for the use of the retail shoe trade. This device is used for smoothing out wrinkles, creases, and irregularities in shoes and otherwise improving their appearance.

Shoe Machinery.—Electric heat has been applied to various machines in shoe factories with marked success. The following table shows various applications of electric heat to standard shoe machinery.

Electrically Heated Shoe Machinery.

Machine.	Application.	No. of Heating Units.	Wattage of Each Unit.
Lining Cementer..........		1	200
Knurling machine.........	Knurl holder......	1	126
Stitcher	Wax pot	2	75
Stitcher	Take-up	1	250
Stitcher	Truck on wax pot.	1	63
Stitcher	Shuttle	1	150
Patent leather repairer....	Wax receptacle....	1	63
Stitcher (old).............	Take-up	1	200
Stitcher (old).............	Shuttle	1	126
Stitcher (old).............	Wax pot..........	2	75
Stamper	Turret	2	182
Embossing machine........	Die holder........	2	121
Embossing machine........	Paste	1	38
Upper leather stamping Machine	Die Holder	1	200
Indenter and burnisher....	Knurl holder	1	126
Welter	Wax pot	2	75
Welter	Looper	1	182
Welter	Tension	1	75
Welter	Thread tube.......	1	38
Embosser	Die Holder	1	300
Goodyear stitch burnisher.	Knurl holder	1	75
Bobbin winder............	Wax pot	2	100
"Expedite"	Burnishing iron...	1	425
"Expedite"	Wax pot..........	1	200
Toe softening machine.....	Boiler	1	750

Solder Pots.—For heating and maintaining correct temperature for soldering operations, electrically heated pots are ideal. They are much cleaner, safer



Westinghouse Solder Pot.

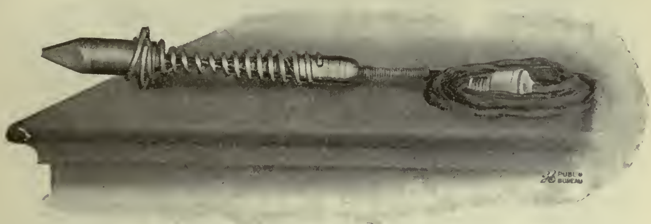
and simpler to operate than the ordinary charcoal or gasoline heated pots. The standard Simplex pots have the following sizes and capacities:

5¾" x 1¼" deep	4 pounds capacity	200 watts	three-heat.
6¾" x 1¼" deep	10 pounds capacity	440 watts	three-heat.
7¾" x 1¼" deep	20 pounds capacity	825 watts	three-heat.

The standard American pots have the following capacities:

5 pounds capacity	400 watts	three-heat.
10 pounds capacity	575 watts	three-heat.
20 pounds capacity	975 watts	three-heat.
50 pounds capacity	1500 watts	three-heat.

Soldering Irons.—Electric soldering irons designed for intermittent use are manufactured in sizes varying from 12 ounces to 3 pounds, and consuming from 75 watts to 350 watts, respectively. The Simplex



G. E. Soldering Iron.

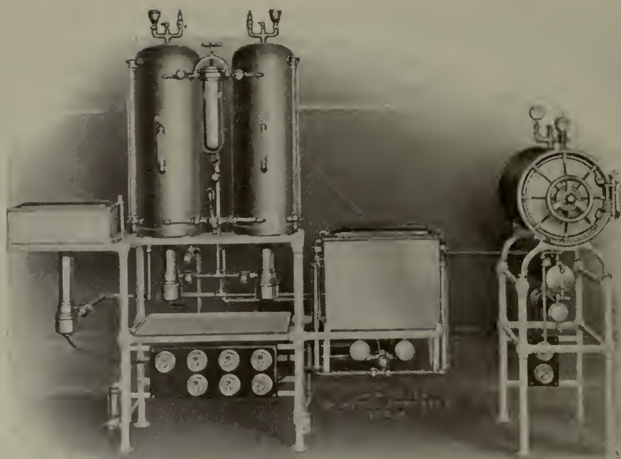
automatic stand, which cuts off one-half the current when the iron is placed upon it, prevents the iron becoming overheated when not in use.

Solution Tanks.—The General Electric Company has devised a means of heating solution tanks with its cartridge units. One 3000 watt installation applied to a tank of 7/16 in. cast iron and having inside dimensions of 18 in. x 18 in. x 14 in., is said to bring a full tank of water to boil in about thirty minutes.

Sterilizers.—The application of electricity to the heating of sterilizers offers a profitable market for energy in nearly every community. All modern hos-

Westinghouse Instrument Sterilizer.

pitals, operating rooms, and dental offices are equipped with sterilizing devices, and the cleanliness, convenience, and healthfulness afforded by electrically heated apparatus appeals to the physician or dentist and creates a favorable impression among his patients.



American Sterilizer Installation. (Left to right—Instrument, Water, Utensil, and Dressing Sterilizers.)

For complete sterilization, dressings are kept under a steam pressure of 15 pounds for about 20 minutes. Water is maintained at 250° F. in closed chambers for approximately the same period, whereas utensils and instruments are submerged in boiling water for about 15 minutes.

Several makes of electrically heated sterilizers are now available. Small instrument sterilizers are made by the Westinghouse, Simplex, Cutler-Hammer, and other heating manufacturers. The American Sterilizer Company makes a complete line of electrically heated apparatus of this character, and the accompanying tables gives the sizes, capacities, and operating features of some of its sterilizers:

Dressing Sterilizers.

			Time and Energy Required for One Sterilization. Initial Temp. 150° F.		
Diam. Inches.	Length Inches.	Kw. Cap.	Minutes High Heat.	Minutes Low Heat.	Kw -hr. Consumed.
9	19	3	14.5	20	.97
12	20	6	13	20	1.8
14	22	6	16.5	20	2.12
16	24	6	18.5	20	2.32
16	30	6	21	20	2.6
16	36	12	15.5	20	4.1

Water Sterilizers.

Gallons Capacity per Reservoir.	Kw. Capacity per Reservoir	Time and Energy Required for One Sterilization. Initial Temp. 150° F. Minutes High Heat.	Minutes Low Heat.	Kw -hr. Consumed.
6	3	40	20	2.25
8	3	44	20	2.45
10	6	30	20	3.5
15	6	40.5	20	4.52
20	12	29.5	20	6.86.
25	12	31.5	20	7.26
35	18	32	20	11.1

Utensil Sterilizers.

Dimensions in Inches. Depth.	Width.	Length.	Kw. Cap.	Time and Energy Required for One Sterilization. Initial Temp. 150° F. 4″ of Water. Minutes High Heat	Minutes Low Heat.	Kw -hr. Consumed.
16	15	20	6	14	15	1.75
20	20	24	6	25	15	2.87
20	24	30	12	37	15	4,1
24	24	30	12	..	..	..

Instrument Sterilizers.

Dimensions in Inches. Depth.	Width.	Length.	Kw. Cap.	Time and Energy Required for One Sterilization. Initial Temp. 150° F. 2″ of Water. Minutes High Heat	Minutes Low Heat.	Kw -hr. Consumed.
6	8	16	3	7.5	15	.55
6	10	20	3	9.5	15	.66
7	12	18	6	6.5	15	.98
7	12	22	6	8	15	1.19
9	12	18	6	6	15	1.
9	12	22	6	8	15	1.2

It should be observed that the energy consumptions and time required for sterilization is based in each case on the use of water with an initial temperature of 150° F. If water at lower temperature is used the time and energy consumption will naturally be increased. The heating units employed are made by the concern solely for its own use. The 3 kw. units have three-heat control and the 6 kw. units have seven heat control.

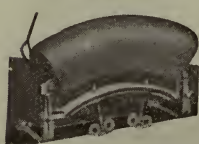
Sweating-On Machines.—An application typical of the advantage of electric heat over the open gas flame is that of the sweating-on machine for mounting copper electrotype shells upon type metal blocks. The block is placed upon the heated plate until the solder foil is melted and the block with the shell upon it is then pressed firmly together and allowed to cool. Cut-

ler-Hammer heating elements applied to machines of this character are said to produce work superior in every way to gas heated apparatus.

Test Tube Heaters.—For laboratory use the Simplex test tube heater is convenient. It consists of an electrically heated grooved casting slightly inclined from the perpendicular, against which the test tubes may be rested. The standard size of this heater is 5 in. x 7⅜ in., and consumes 500 watts.

Thread Waxer Heater.—A wax receptacle of a stitching machine may be heated electrically by attaching a low wattage unit to the bottom. A number of these heaters are in successful use. They eliminate all the dangers and discomforts of gas operation and are far more convenient and cleanly.

Tire Vulcanizers.—For light automobile tire repairs the electric vulcanizer is ideal. Sand blisters, cuts and stone bruises can be repaired without removing the tire, and as the work can be done promptly with a handy device of this kind, it will save much tire expense. The heat is evenly distributed over the surface and the work may be done neatly and quickly.



Shaler Type C Inside Casing Form.

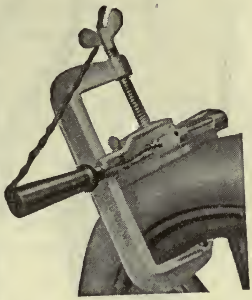
Shaler Type E Tube Vulcanizer.

The C. A. Shaler Co. manufactures a complete line of electrically heated vulcanizing forms, which it claims to be equal or superior to its steam devices. Some of the advantages set forth are simplicity, portability, quick heating, safety and non-confliction with any garage regulations. Each device may be purchased separately, attached to any work bench, and used for its own distinct class of work. The capacities of the standard devices are as follows:

Type A—Outside casing form........................ 70 watts
Type C—Inside casing form......................... 80 watts
Type E—"Gang" or multi-tube form (4½" x 24")....200 watts

The Westinghouse automobile tire vulcanizer consumes a maximum of 200 watts. It is furnished with a 15-point rheostat, a thermometer, and a flexible cord.

Westinghouse Outside Casing Vulcanizing Outfit.

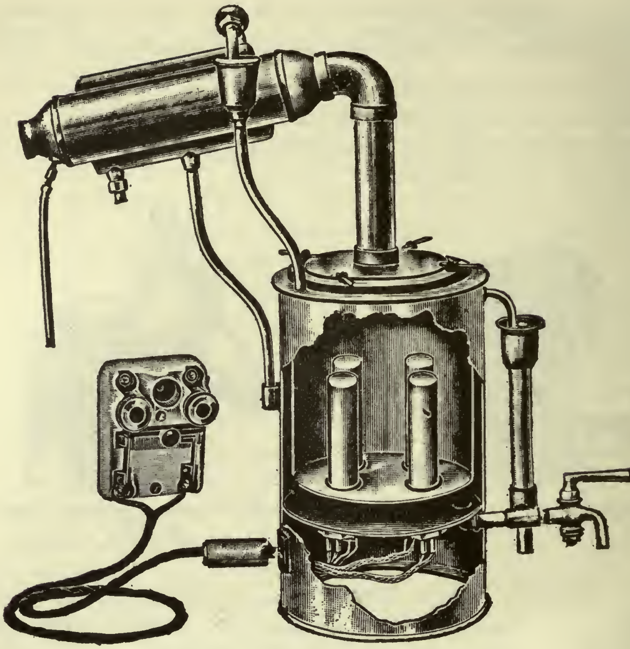


Shaler Type A Outside Casing Form.

Varnish Tank Heater.—A well-lagged varnish tank 5 ft. high and 3 ft. in diameter, located near the roof of a factory, and used for spraying automobile bodies, has been heated by three 3-heat, 900-watt cartridge units for some time. The units are placed in a 10 in. x 6 in. x 3 in. box of sand, mounted ½ in. from the bottom of the tank, and the leads are brought out through a ¾ in. conduit.

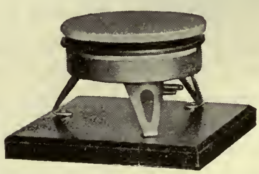
Velvet Marking Iron.—A 150 watt General Electric iron having a body 1 in. square by 6 in. long and a bottom surface ¾ in. wide by 6 in. long, is being used by the J. B. Martin Co. of Norwich, Conn., for marking letters and numbers on velvet cloth. A gummed cloth label is cemented in place by the heat and pressure of the iron.

Water Stills. — Electrically heated water stills equipped with General Electric heating units have been developed by the Barnstead Water Still Company of Boston. It is claimed by the manufacturers that a 2400 watt still will provide one gallon of distilled water per hour.



E. & A. Barnstead Type L Water Still.

Wax Burning-In Irons.—Electrically heated burning-in irons are useful in furniture factories and stores for burning in wax. They are usually made in one pound sizes and are similar to soldering irons in design.



G. E. Wax Knife Heater.

Wax Knife Heater.—General Electric wax knife heaters are superior to all fuel heated devices used by cabinet finishers. The standard type is similar to a 4-inch disc stove, consumes 180 watts and is designed

with an insulating cover, under which the knife is placed.

Weight Reducing Cabinet. — A galvanized iron cabinet 18 in. in diameter, lined with 1/4 in. asbestos, has been equipped by the General Electric Company with two of its tubular type 500 watt heating units. Arrangement is made for heat regulation so that the attendant may vary the temperature to suit the patient's needs.

Yarn Conditioning Oven.—This device is manufactured by the Tillotson Humidifier Company of Providence, R. I. It is used for measuring the moisture in yarns by weighing before and after drying. It is well insulated and thermostatically controlled. The oven is heated with two General Electric 600 watt units.

CHAPTER XVII

RATES FOR HEATING SERVICE.

Establishing of Rates.—Electric heating service usually differs from lighting and motor service in its value to the user and in the character of load it adds to the central station lines. If the load created by any class of service is sufficiently attractive to warrant the central station in making rates for it that are equal to or less than its value to the user, it is apparent that an ideal condition exists. If the rate is of necessity higher than the customer is justified in paying for the service rendered, business of such character is not developed, and the buyer is forced to obtain the same or equivalent service elsewhere at a less cost. On the other hand, if the rate must be made so low to obtain the customer's business, that the additional expense involved is greater than the additional income secured, the central station would not be justified in making such a rate.

Heating Loads.—The character of heating loads varies widely on account of the diversity of application. From an operating standpoint, they are usually more attractive than other classes of load. With few exceptions they are non-inductive. As they generally operate over long hour periods, they tend to improve the central station load factors. Fluctuations of the current demand are less marked, and as many electrically heated appliances naturally take, or can be made to take, energy only during off-peak hours, the advantages are obvious. The opportunity for building up cooking and heating loads along existing residential and rural lines, which have heretofore required enormous investment in proportion to gross income, is apparent.

Rate Maker's Difficulties.—Many central station managers, realizing the profitable nature of the electric

heating business and the demand for such rates as will foster its development, have been anxious to make tariff revisions, but have been undecided as to the proper course to pursue by the apparent adverse attitude of press, public and the various regulating bodies.

As a whole, the public is notoriously ill-informed on central station rate making principles, and is prone to criticise the motives actuating those who make rates for certain classes of service lower than established rates for other classes. Furthermore, the attitude of the public has often been reflected in the actions and decisions of public service commissions. The fear of criticism, and the dread of establishing harmful precedents that might be used against them, deter many responsible concerns from making rates designed to attract new and profitable business, in spite of their positive convictions that such action would be productive of good for those directly concerned, as well as for the public at large.

It may be observed that the fear of popular criticism and the dread of having all service rates reduced by commission rulings, in proportion as individual rates are lowered, are for the most part unfounded. Any downward revision that may tend to improve living conditions, develop new industries, or result in greater good for a greater number, must eventually meet with universal favor. On the other hand, harsh criticism must sooner or later come upon those who do not offer their customers the benefit of such rates as they can well afford and as will make for their mutual welfare.

N. E. L. A. Rate Principles.—The six principles set forth in the 1915 report of the Rate Research Committee of the National Electric Light Association are really the basis of intelligent rate making in the electric industry, as well as in the railroad and other industries.

"(1) The total net income of the company must be enough and no more than enough to give a fair return on the investment and attract capital freely to the enterprise. The gross earnings from the sale of

the product must therefore be sufficient to cover all necessary expenses of operation, including taxes, bad debts, etc., a reserve for renewals and contingencies, interest at current rates and a reasonable profit in addition.

"(2) When conditions are the same, rates to different customers or classes should be the same, but need not necessarily be the same when conditions are different.

"(3) No rate should be below the bare cost, i. e., below the expense involved by adding that customer or class, including a fair return on any investment added or used exclusively for that customer or class.

"(4) Rates should be such that as many customers as possible may be served at as low rates as possible, and yet the business as a whole furnish a fair return on all the investment.

"(5) No rate can be above the value of service, otherwise the customer will not take it.

"(6) While cutomers whose circumstances are alike should pay the same rates, it is not necessary that customers whose circumstances are unlike in respect to the amount their class can afford to pay, should be asked to pay the same percentage on the investment they use jointly, especially when they would not take the service if asked to pay such rates, but, on the other hand, would take the service and pay something toward the fair return on the whole investment if offered rates they could afford to pay.

Application of Principles to Heating Rates.—It is apparent that in applying the Rate Committee's principles to the establishment of rates designed to develop certain heating loads, the central station is justified in making rates based upon the actual cost of supplying the service, plus a reasonable return upon the additional portion of the investment required to supply it. It is not essential that the income derived from the application of a rate shall be adequate to earn a return upon the total plant investment involved in supplying it.

Each central station company must decide for itself what rates it shall adopt, because the matter is one that naturally depends almost entirely on local conditions. It is obvious that the present tendency is toward wholesale rather than retail energy supply and rates must be based accordingly. The fact should be kept in mind in all considerations of rate matters that a mere statement of rate per kilowatt hour does not mean very much. The individuals who have their money invested are much more interested in annual returns than in hourly revenues.

APPENDIX.

Containing References and Tables.

Electric Heating Manufacturers.

Advance Machinery Co..............................Toledo, Ohio
Glue cookers and pots.
American Electric Heater Co...................Detroit, Mich.
Domestic cooking and heating devices.
Industrial heating apparatus.
American Ironing Machine Co..166 No. Michigan Ave., Chicago
Simplex ironing machines.
American Laundry Mach. Co..................Cincinnati, Ohio
Mangles.
Armstrong Cork & Insulation Co..............Cincinnati, Ohio
Heat insulating materials

Barnstead Water Still Co........................Boston, Mass.
Water stills.

C. A. Shaler Co..................................Waupun, Wis.
Vulcanizers.
Chicago Dryer Co................624 So. Wabash Ave., Chicago
Clothes dryers.
C. H. Sharp Mfg. Co..............1312 E. 12th St., Los Angeles
Electric ranges.
C. L. McBride Mfg. Co............................Toledo, Ohio
Glove stretchers and laying-off boards.
Coin Machine Mfg. Co..........................Portland, Ore.
Induction water heaters.
Induction linotype pots.
Cutler-Hammer Mfg. Co....144th St. and Southern Blvd., N. Y.
Industrial heating apparatus.
Domestic heating devices.
C. W. Leavitt & Co...........Cortlandt Bldg., New York, N. Y.
Girod steel furnaces.

Driver-Harris Wire Co.........................Harrison, N. J.
Resistance wire.

Efficiency Products Co..............Rialto Bldg., San Francisco
Water heaters.
Eimer & Amend Co..........205 Third Ave., New York, N. Y.
Industrial and laboratory heating devices.
Electric Sales Corporation........418 Union St., Seattle, Wash.
"Apfel" Water Heaters.
Electric Sales Service Co......109 Stevenson St., San Francisco
"Therm Elect" water heaters.
Bacteriological incubators.
Electric Specialty Co......... ....Salt Lake City, Utah
Chicken incubators and brooders.
Electro Hatch Incubator Co.....................Petaluma, Cal.
Chicken incubators and brooders.
Estate Stove Company..........................Hamilton, Ohio
Domestic ranges.

General Electric Co........................Schenectady, N. Y.
Domestic heating and cooking devices.
Hotel and domestic ranges.
Industrial heating devices.
Geuder, Paschke & Frey Co...................Milwaukee, Wis.
Butt welders.
Globe Stove & Range Co........................Kokomo, Ind.
Domestic ranges.
Good Housekeeping Cooker Co..................Berkeley, Cal.
Automatic cookers and water heaters.

Hamilton & Hansell................17 Battery Place, New York
Rennerfelt furnaces.
Hoskins Manufacturing Co.....................Detroit, Mich.
Small furnaces and heating devices.
Hospital Supply Co..................55 Fifth Ave., New York
Sterilizers. .
Hotpoint Electric Heating Co...................Ontario. Cal.
Domestic heating and cooking devices.
Electric ranges.
Hughes Electric Heating Co........211 W. Schiller St., Chicago
Domestic and commercial cooking devices.
Bake ovens, etc.
H. W. Johns-Manville Co......................New York, N. Y.
Heat insulating materials.

James L. Gibney & Bro............................Philadelphia
Vulcanizers.
James B. Clow & Sons................342 Franklin St., Chicago
Bath cabinets.

Landers, Frary & Clark...................New Britain, Conn.
Domestic heating and cooking devices.
Lee Electric Radiator Co............335 Wells St., Chicago, Ill.
Water heaters and radiators.
Lincoln Electric Co......E. 38th St. and Kelley Ave., Cleveland
Arc Welders.

Majestic Electric Development Co.........428 O'Farrell St., S. F.
Radiant air heaters.
Michigan Stove Co..............................Detroit, Mich.
Domestic ranges.

National Electric Utilities Co............103 Park Ave., N. Y.
Hotel and domestic ranges.
National Electric Welder Co....................Warren, Ohio
Spot, butt and seam welders.

Pelton & Crane Co.............244 Harper Ave., Detroit, Mich.
Furnaces for jewelers and opticians.
Petaluma Incubator Co..........................Petaluma, Cal
Chicken incubators and brooders.
Prometheus Electric Co............232 E. Third St., New York
Sterilizers, radiators, etc.
Presto Electric Co.................323 Geary St., San Francisco
Dental heating devices.

Rathbone, Sard & Co............................Albany, N. Y.
Domestic ranges.
Rutenber Electric Co.........................Logansport, Ind.
Domestic ranges.

Scanlan-Morris Co..............................Madison, Wis.
Sterilizers.
Siemund, Wenzel Electric Welding Co......30 Church St., N. Y.
Welding machines.
Simplex Electric Heating Co.................Cambridge, Mass
Domestic heating and cooking devices.
Hotel and domestic ranges.
Industrial heating devices.
Snyder Electric Furnace Co.......................Chicago, Ill
Steel furnaces.
Standard Electric Stove Co.........1718 No. 12th St., Toledo, O.
Domestic ranges.

Thomson Electric Welder Co..................Warren, Ohio
Welding machines.

Union Fibre Co..............................Winona, Minn.
Heat insulating materials
United Sales Company............Hobart Bldg., San Francisco.
Automatic water faucets.
United States Steel Corporation.................Hoboken, N. J.
Heroult steel furnaces.

Vulcan Electric Heating Co....107 W. 13th St., New York, N. Y.
Branding irons.

Wenborne-Karpen Dryer Co........900 Michigan Ave., Chicago
Varnish dryers.

Westinghouse Electric & Mfg. Co..........East Pittsburgh, Pa.
Domestic heating and cooking devices.
Domestic ranges.
Industrial heating devices.

Wilmot, Castle Co............................Rochester, N. Y.
Sterilizers.

Winfield Electric Welding Machine Co............Warren, Ohio
Welding machines.

Wm. B. Berry & Co.................79 North St., Boston, Mass.
Corn poppers and peanut roasters.

Conversion Data.

1 kw-hr. = 3412 B.t.u.
1 watthour = 3.412 B.t.u.
1 wattminute = .0568 B.t.u.
1 wattsecond = .0009477 B.t.u.
1 large calorie = 3.968 B.t.u.
1 kw-hr. = 859.975 large calories.
1 watthour = .859975 large calorie.
1 wattminute = .01433 large calorie.
1 wattsecond = .000239 large calorie.
1 gallon (U. S.) water contains 231 cu. in. or .1337 cu. ft.
1 cu. in. of water contains .00433 gal. and weighs .0361 lb.
1 cu. ft. of water contains 7.48 gal., and weighs 62.428 lb.
1 pound of water = 27.68 cu. in.
1 pound of water = .958 pint.
1 kilogram of water = 1000 cu. cm.
1 kilogram of water = 1.0567 quarts.
1 B.t.u = .000293 kw-hr.
1 B.t.u. = .293027 watthour.
1 B.t.u = 17.58 wattminutes.
1 B.t.u. = 1054.9 wattseconds
1 B.t.u. = .25199 large calorie.
1 large calorie = .001163 kw. hr.
1 large calorie = 1.163 watthours.
1 large calorie = 69.769 wattminutes.
1 large calorie = 4186.17 wattseconds.
1 large calorie = 1000 small calories.
1 gram of water = 1 cubic centimeter.
1 pound of water = 453.592 cu. cm.
1 kilogram of water = 61.023 cu. in.
1 kilogram of water = .035314 cu. ft.

Resistance of Conductors at Various Temperatures.

$R_t = R_o (1 + xt)$.
R_t = resistance at temperature t.
R_o = resistance at temperature given in standard tables.
x = temperature co-efficient. (Table I.)
t = difference between R_o and R_t.

Table I—Relative Resistance and Temperature Coefficient.

Pure Metals.	Relative Resistance in per cent.	Temp. Coef. Fahrenheit (x)
Silver annealed	92.5	.00222
Copper annealed	97.5	.00242
Copper (Standard)	100.0	......
Gold 99.9 per cent	138	.00210
Aluminum 99 per cent	161	.00235
Zinc	362	.00226
Platinum annealed	565	.00137
Iron	570	.00347
Nickel	778	.00345
Tin	828	.00245
Lead	1,280	.00228
Antimony	2,210	.00216
Mercury	5,930	.00044
Bismuth	8,220	.00197
Nichrome (alloy)	....	.00024

Table II.—Relation of Load Factor and Kilowatt-Hour Consumption.

Load Factor per cent.	Kw-hr. per Year per kw.	Kw-hr. per Month per kw.	Load Factor per cent	Kw-hr. per Year per kw.	Kw-hr. per Month per kw.
100	8760	730	50	4380	365
90	7884	657	40	3504	292
80	7008	584	30	2628	219
70	6132	511	20	1752	146
60	5256	438	10	876	73

Table III.—Relative Radiating and Reflecting Power of Different Substances (Kent).

	Radiating or Absorbing Power.	Reflecting Power.
Lampblack	100	0
Water	100	0
Carbonate of lead	100	0
Writing paper	98	2
Ivory, jet, marble	93 to 98	7 to 2
Ordinary glass	90	10
Ice	85	15
Gum lac	72	28
Silver-leaf on glass	27	73
Cast iron, bright polished	25	75
Mercury, about	23	77
Wrought iron, polished	23	77
Zinc, polished	19	81
Steel, polished	17	83
Platinum polished	24	76
Platinum, in sheet	17	83
Tin	15	85
Brass, cast, dead polished	11	89
Copper, varnished	14	86
Brass, bright polished	7	93
Copper, hammered	7	93
Gold, plated	5	95
Gold on polished steel	3	97
Silver, polished bright	3	97

Table IV.—Transmission of Heat Through Plates and Tubes from Steam or Hot Water to Air. (Kent).

(B.t.u. per hour per sq. ft. per degree Fahr. difference.)

Copper, polished	.0327	Sheet-iron, ordinary	.5662
Tin, polished	.0440	Glass	.5948
Zinc and brass, polished	.0491	Cast iron, new	.6480
Tinned iron, polished	.0858	Common steam-pipe, inferred	.6400
Sheet iron, polished	.0920	Cast and sheet iron,, rusted	.6868
Sheet lead	.1329		
Wood, building stone, and brick	.7358		

Table V.—Boiling Points at Atmospheric Pressure
14.7 lb. per square inch. (Kent).

	Deg. F.		Deg. F.
Ether, sulphuric	100	Av. sea water	213.2
Carbon bisulphide	118	Saturated brine	226
Ammonia	140	Nitric acid	248
Chloroform	140	Oil of turpentine	315
Bromine	145	Phosphorus	554
Wood spirit	150	Sulphur	570
Alcohol	173	Sulphuris acid	590
Benzine	176	Linseed oil	597
Water	212	Mercury	676

The boiling points of liquids increase as the pressure increases. The boiling point of water at any given pressure is the same as the temperature of saturated steam of the same pressure.

Table VI.—Latent Heat of Fusion.

Substance.	Latent Heat of Fusion in B.t.u.	Substance.	Latent Heat of Fusion in B.t.u.
Bismuth	22.75	Silver	37.93
Cast iron, gray	41.4	Beeswax	76.14
Cast iron, white	59.4	Paraffine	63.27
Lead	9.66	Spermaceti	66.56
Tin	25.65	Phosphorus	9.06
Zinc	50.63	Sulphur	16.86
Ice	144.		

Table VII.—Melting-Points of Various Substances. (Kent).

	Deg. F.		Deg. F.
Sulphurous acid	— 148	Alloy, 1 tin, 1 lead	370 to 466
Carbonic acid	— 108	Tin	442 to 446
Mercury	— 39	Cadmium	442
Bromine	+ 9.5	Bismuth	504 to 507
Turpentine	14	Lead	608 to 618
Hyponitric acid	16	Zinc	680 to 779
Ice	32	Antimony	810 to 1150
Nitro-glycerine	45	Aluminum	1157
Tallow	92	Magnesium	1200
Phosphorus	112	Calcium	Full red heat
Acetic acid	113	Bronze	1692
Stearine	109 to 120	Silver	1733 to 1873
Spermaceti	120	Potassium sulphate	1859
Margaric acid	131 to 140	Gold	1913 to 2282
Potassium	136 to 144	Copper	1929 to 1996
Wax	142 to 154	Cast iron, white	1922 to 2075
Stearic acid	158	Cast iron, gray	2012 to 2228
Sodium	194 to 208	Steel	2372 to 2532
Alloy, 3 lead, 2 tin and 1 bismuth	199	Steel hard, 2570; mild	2687
Iodine	225	Wrought iron	2732 to 2912
Sulphur	239	Palladium	2732
Alloy, 1½ tin, 1 lead	334	Platinum	3227

Cobalt, nickel, and manganese, fusible in highest heat of a forge. Tungsten and chromium, not fusible in forge, but soften and agglomerate. Platinum and iridium, fusible only before the oxyhydrogen blowpipe.

Table VIII.—Specific Gravity of Substances.

$$\text{Sp.Gr.} = \frac{\text{Wt. of substance.}}{\text{Wt. of equal bulk of pure water.}}$$

Substance.	Average Sp. Gr.	Pounds per cu. ft.
Metals:		
Aluminum	2.67	166.5
Antimony	6.76	421.6
Bismuth	9.82	612.4
Brass: Copper + Zinc)		
80 20	8.60	536.3
70 30	8.40	523.8
60 40	8.36	521.3
50 50	8.20	511.4
Bronze: Copper, 95 to 80	8.53	552.0
Tin, 5 to 20	8.53	552.0
Cadimum	8.65	539.
Gold, pure	19.258	1200.9
Copper	8.853	552.
Iron, Cast	7.218	450.
Iron, Wrought	7.70	480
Lead	11.38	709.7
Manganese	8.	499.
Magnesium	1.75	109.
Mercury 32°	13.62	849.3
Mercury 60°	13.58	846.8

Substance.	Average Sp. Gr.	Pounds per cu. ft.
Mercury, 212°	13.38	834.4
Nickel	8.8	548.7
Platinum	21.5	1347.0
Silver	10.505	655.1
Steel	7.854	489.6
Tin	7.35	458.3
Zinc	7.00	436.5
Wood:		
Ebony	1.23	76
Oak, Live	1.11	69
Cedar	.62	39
Pine, White	.45	28
Pine, Yellow	.61	38
Cork	.24	15
Stones, Brick, Cement, etc.:		
Asphaltum	1.39	87
Brick, Soft	1.6	100
Brick, Common	1.79	112
Brick, Hard	2.0	125
Brick, Pressed	2.16	135
Brick, Fire	2.32	145
Brickwork in mortar	1.6	100
Brickwork in cement	1.79	112
Cement, Rosendale, loose	.96	60
Cement, Portland, loose	1.25	78
Clay	2.16	135
Concrete	2.08	130
Earth, loose	1.22	76
Earth, rammed	1.60	100
Emery	4.	250
Glass	2.63	164
Glass, flint	3.02	188
Gneiss	2.64	165
Granite	2.64	165
Gravel	1.76	110
Gypsum	2.24	140
Hornblende	3.36	210
Lime, quick, in bulk	.84	53
Limestone	2.96	185
Magnesia, Carbonate	2.4	150
Marble	2.72	170
Masonry, dry rubble	2.40	150
Masonry, dressed	2.56	160
Mortar	1.52	95
Pitch	1.15	72
Plaster of Paris	1.23	77
Quartz	2.64	165
Sand	1.60	100
Sandstone	2.32	145
Slate	2.80	175
Stone, various	2.78	168
Trap	3.06	185
Tile	1.84	115
Soapstone	2.73	170
Liquids (at 60° F.):		
Acid, Muriatic	1.200	....
Acid, Nitric	1.217	....
Acid, Sulphuric	1.849	....
Alcohol, pure	.794	....
Alcohol, 95%	.816	....
Alcohol, 50%	.934	....
Ammonia, 27.9%	.891	....
Bromine	2.97	....
Carbon disulphide	1.26	....
Ether, Sulphuric	.72	....
Oil, Linseed	.94	....
Oil, Palm	.97	....
Oil, Olive	.92	....
Oil, Petroleum	.83	....

Substance.	Average Sp. Gr.	Pounds per cu. ft.
Oil, Rape	.92	....
Oil, Turpentine	.87	....
Oil, Whale	.92	...
Tar	1.	....
Vinegar	1.08	....
Water	1.	....
Water, Sea	1.028	....
Gases (at 62° F. Water = 1):		
Oxygen	0.001350	0.0814
Nitrogen	0.001185	0.0738
Hydrogen	0.0000846	0.00527
Argon	0.001607	......
Carbon	0.001013	0.63131
Phosphorus	0.0026221	0.16337
Sulphur	0.002705	0.16861
Silicon	0.001184	0.07378
Air	0.001221	0.0761
Water-vapor	0.0007613	0.04745
Ammonia	0.00118	0.0448
Carbon monoxide (Carbonic oxide)	0.002369	0.07364
Carbon dioxide (Carbonic acid)	0.00187	0.11631
Olefiant gas	0.001181	0.0736
Marsh gas	0.000675	0.04209
Sulphurous acid	0.002493	0.15536
Sulphuretted hydrogen	0.002877	0.17918
Bisulphuret of carbon	0.00643	0.40052
Ozone	0.00203	0.12648

*By this table there would be 12.75 cubic feet of air at 32° F. per pound.

The specific heats of substances, as given by different authorities, show considerable lack of agreement, especially in the case of gases.

The following tables give the mean specific heats of the substances named according to Regnault. These specific heats are average values, taken at temperatures which usually come under observation in technical application. The actual specific heats of all substances, in the solid or liquid state, increase slowly as the body expands or as the temperature rises. The specific heat of a body when liquid is greater than when solid. For many bodies this has been verified by experiment.

Table IX.—Specific Heats of Various Substances. (Kent.)

Solids.

Antimony	0.0508	Steel (soft)	0.1165
Copper	0.0951	Steel (hard)	0.1175
Gold	0.0324	Zinc	0.0956
Wrought Iron	0.1138	Brass	0.0939
Glass	0.1937	Ice	0.5040
Cast Iron	0.1298	Sulphur	0.2026
Lead	0.0314	Charcoal	0.2410
Platinum	0.0324	Alumina	0.1970
Silver	0.0570	Phosphorus	0.1887
Tin	0.0562		

Liquids.

Water	1.0000	Mercury	0.333
Lead (melted)	0.0402	Alcohol (absolute)	0.7000
Sulphur (melted)	0.2340	Fusel oil	0.5640
Bismuth (melted)	0.0308	Benzine	0.4500
Tin, (melted)	0.0637	Ether	0.5034
Sulphuric acid	0.3350		

Gases.

	Constant Pressure.	Constant Volume.
Air	0.23751	0.16847
Oxygen	0.21751	0.15507
Hydrogen	3,40900	2.41226
Nitrogen	0.24380	0.17273
Superheated steam	0.4805	0.346
Carbonic acid	0.217	0.1535
Olefiant Gas (CH_2)	0.404	0.173
Carbonic oxide	0.2479	0.1758
Ammonia	0.508	0.299
Ether	0.4797	0.3411
Alcohol	0.4534	0.3200
Acetic acid	0.4125	......
Chloroform	0.1567	......

Table X.—Lineal Expansion of Solids at Ordinary Temperatures.

(Clark.)

	For 1° Fahrenheit. Length = 1
Aluminum (cast)	.00001234
Antimony (cryst.)	.00000627
Brass, cast	.00000957
Brass, plate	.00001052
Brick	.00000306
Bronze (Copper, 17; Tin, 2½; Zinc, 1)	.00000986
Bismuth	.00000975
Cement, Portland (mixed), pure	.00000594
Concrete; cement, mortar, and pebbles	.00000795
Copper	.00000887
Ebonite	.00004278
Glass, English flint	.00000451
Glass, thermometer	.00000499
Glass, hard	.00000397
Granite, gray, dry	.00000438
Granite, red, dry	.00000498
Gold, pure	.00000786
Iridium, pure	.00000356
Iron, wrought	.00000648
Iron, cast	.00000556
Lead	.00001571
Magnesium	....
Marbles, various, from .00000308 to	.00000786
Masonry, brick, from .00000256 to	.00000494
Mercury (cubic expansion)	.00009984
Nickel	.00000695
Pewter	.00001129
Plaster, white	.00000922
Platinum	.00000479
Platinum, 85 per cent	.00000453
Iridium, 15 per cent	.00000453
Porcelain	.00000200
Quartz, parallel to major axis, t 0° to 40° C.	.00000434
Quartz, perpendicular to major axis, t 0° to 40° C.	.00000788
Silver, pure	.00001079
Slate	.00000577
Steel, cast	.00000636
Steel, tempered	.00000689
Stone (sandstone) dry	.00000652
Stone (sandstone) Rauville	.00000417
Tin	.00001163
Wedgewood ware	.00000489
Wood, pine	.00000276
Zinc	.00001407
Zinc 8, tin 1	.00001496

Cubical expansion or expansion of volume = linear expansion × 3

Table XI.—Character of Emitted Light and Corresponding Approximate Temperature. (Babcock and Wilcox.)

Character of Emitted Light.	Temp. F.°
Dark red, blood red, low red	1050
Dark cherry red	1175
Cherry, full red	1375
Light cherry, bright cherry and light red	1550
Orange	1650
Light Orange	1725
Yellow	1825
Light Yellow	1975
White	2200

*(Character of emitted light and corresponding temperatures approximately the same for all materials).

Table XII.—Weight of Water at Temperature Used in Standard Calculations. (Babcock & Wilcox—"Steam").

Temperature Degrees Fahrenheit.	Weight per cu. ft. in Pounds.
At 32° freezing point at sea level	62.418
At 39.2° or point of maximum density	62.427
At 62° or standard temperature	62.355
At 212° or boiling point at sea level	59.846

Table XIII.—Variations in Properties of Saturated Steam with Pressure.

(From Marks & Davis Tables.)

Pressure Pounds Absolute.	Temperature Degrees Fahrenheit.	Heat of Liquid B.t.u,	Latent Heat B.t.u,	Total Heat B.t.u.
14.7	212.0	180.0	970.4	1150.4
20.00	228.0	196.1	960.0	1156.2
100.00	327.8	298.3	888.0	1186.3
300.00	417.5	392.7	811.3	1204.1

Table XIV.—Saturated Steam. (From Marks & Davis' Steam Tables.)

Gauge Pressure.	B.t.u.	Total B.t.u. in Steam.
10	161.1	1143.1
20	196.1	1156.2
30	218.8	1163.9
40	236.0	1169.4
50	250.1	1173.6
60	262.1	1177.0
70	272.6	1179.8
80	282.0	1182.3
90	290.5	1184.4
100	298.3	1186.3
110	305.5	1188.0
120	312.3	1189.6

Table XV.—Calorific Values of Dry Wood. (Gottlier.)

Kind of Wood.	B.t.u. per lb.
Oak	8316
Ash	8480
Elm	8510
Beech	8591
Birch	8586
Fir	9063
Pine	9153
Poplar	7834*
Willow	7926*

*B.t.u. calculated.

Table XVI—Calorific Value of General Grades of Coal on Basis of Combustible. (Approximate.)

	Per Cent of Combustible. Fixed Carbon.	Volatile Matter.	B.t.u. Per Pound of Combustible.
Antracite	97.0 to 92.5	3.0 to 7.5	14600 to 14800
Semi-anthracite	92.5 to 87.5	7.5 to 12.5	14700 to 15500
Semi-bituminous ...	87.5 to 75.0	12.5 to 25.0	15500 to 16000
Bituminous—Eastern	75.0 to 60.0	25.0 to 40.0	14800 to 15300
Bituminous—Western	65.0 to 50.0	35.0 to 50.0	13500 to 14800
Lignite	Under 50	Over 50	11000 to 13500

Table XVII.—Calorific Value of Various Oils.

Kind of Oil.	B.t.u. per. lb.	Authority.
California, Coalinga	17117	Babcock & Wilcox
California, Bakersfield	17600	Wade
California, Bakersfield	18257	Wade
California, Kern River.........	18845	Babcock & Wilcox
California, Los Angeles........	18328	Babcock & Wilcox
California, Los Angeles........	18855	Babcock & Wilcox
California, Los Angeles........	18280	Babcock & Wilcox
California, Monte Christo......	18878	Babcock & Wilcox
California, Whittier	18507	Wade
California, Whittier	18240	Wade
Texas, Beaumont	20152	Sparkes
Texas, Beaumont	19349	Babcock & Wilcox
Texas, Sabine	18662	Babcock & Wilcox
Ohio	19580	
Pennsylvania	19210	Booth s
West Virginia.................	21240	
Mexico	18840	Babcock & Wilcox

Table XVIII.—Calorific Values of Natural Gas.

Locality of Well.	B.t.u per cu. ft. Calculated.*
Anderson, Ind..........................	1017
Marion, Ind............................	1009
Muncie, Ind............................	1004
Olean, N. Y............................	1018
Findlay, O.............................	1011
St. Ive, Pa............................	1117
Cherry Tree, Pa........................	842
Grapeville, Pa.........................	925
Harvey Well, Butler Co.*...............	998
Pittsburgh, Pa.........................	748
Pittsburgh, Pa.........................	917
Pittsburgh, Pa.........................	899

*B.t.u. Approximate.

Table XIX—Approximate Calorific Values of Various Gases (Kent)

Kind of Gas.	B.t.u. per Cu. Ft.
Natural gas	1,000
Coal gas	675
Carburetted water gas.......................	646
Gasoline gas	690
Water gas from coke.........................	313
Water gas from bituminous coal..............	377
Producer gas	150
Naptha-gas (2½ gal. per 1000 cu. ft)........	306

Table XX.—Refractory Materials (Stansfield.)

Material.		Melting Temperature Deg. F.
Fire-clay brick. Kaolin with additional silica		2900 to 3150
Silica-brick. Silica with binding material		3100
Silica (pure)		3180
Bauxite (impure alumina)		3300
Alumina (pure)		3650
Lime (pure)	about	3700
Chrome-brick		3700
Chromite		3950
Magnesia-brick		3900
Magnesia (pure)	about	4000
Carborundum, SiC	decomposes	4000
Carbon	vaporizes rapidly	6500

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